JOURNAL

OF

THE FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

NOVEMBER, 1865.

CIVIL ENGINEERING.

Railway Over the Mont Cenis.

From the Civil Engineer and Architect's Journal, August, 1865.

A series of official trials on the proposed railway over Mont Cenis, to be used during the construction of the celebrated tunnel through the mountain, has just been concluded. Captain Tyler, R.E., was commissioned by the English government to be present at these trials, and to report thereon, which he has recently done. The experiments were to be made with the loads, and at the rate of speed required to carry out the programme of the projectors for trains crossing the mountain between Susa and St. Michel, carrying fifty passengers, their baggage, and the mail, and performing the distance in 4½ hours. But throughout the trials the stipulated speed was exceeded. The portion of the high road over the Cenis that has been granted for the the railway line is the outside skirting; that is to say, the edge of the precipice. Measures had to be taken to obviate risk, and persons who have well examined and repeatedly traveled over the portion of the line already constructed, have expressed a most decided opinion in favor of its safety. Until the contractors had thoroughly satisfied themselves of the possibility of securing complete safety, it would have been folly for them to embark at all in the undertaking.

There is a break of 47·6 English miles, from St. Michel to Susa, in the railway communication between France and Italy by the Mont Cenis route, and the contract time allowed for traveling by diligence between those two places is 9 hours in summer, and 10½ in winter. The

passage of the mountain, which may be said to commence on the French side at Lanslebourg, is by an excellent road, 9 to 10 metres (say 30 to 32 feet) in width, and on an average gradient of 1 in 13; but the traffic is much impeded during the winter season by snow; and considerable risk is incurred in some states of the weather from the fall of avalanches, and from the difficulty of guiding the heavy diligences over ice and snow in the descent. During portions of the winter, indeed, the service is performed by sledges, and the time occupied by the journey is uncertain, depending on the state of the weather.

To save time, and to obviate the inconveniences of this passage, the Grand Tunnel of the Alps is in course of construction between Modane and Bardonèche for a length of 12,220 metres (7·593 miles). In this tunnel, headings have been driven for 2011 metres from Modane, and 2700 metres from Bardonèche, leaving 7509 metres (about 4⅔ English miles) to be pierced. The boring machines in this tunnel, ingeniously contrived by Messrs. Sommeiller, Grandis & Grattoni, are worked by air, which is compressed to five atmospheres by water-wheels in the valley below, and about a mile and a half distant from them, and the headings are formed by successive explosions of gunpowder, in the usual way, as soon as the holes, about 3 feet deep, have been formed (and tamped) in the rock.

It is stated that 400 horse power has been exerted by five of these water-wheels at Modane, to provide 27 horse power working nine jumpers at the face of the excavation, and to afford indifferent ventilation (except at the spot where the boring machine is at work) to the interior, while £8000, or more, has been recently expended in constructing cylindrical boiler-shaped reservoirs for compressed air, to contain a supply sufficient for about half a day's working in the tunnel. These reservoirs are filled during the intervals when the boring machines are not at work.

Captain Tyler states that, "looking to the rate of progress which has hitherto been effected, and the probable nature of the rocks, it cannot be expected, without taking into account any extra difficulties of ventilation, or from water, which may be encountered, that this tunnel can be completed in less than from seven to eight years. There are other works also on the permanent railway, as at present projected, including other tunnels, which will occupy many years in construction."

Under these circumstances, Mr. J. B. Fell has proposed to the French and Italian governments, on behalf of Messrs. Brassey & Co., to construct a railway from St. Michel, over the Mont Cenis, to Susa, to be used pending the completion of the grand tunnel, and the permanent railway to be connected with it. Mr. Fell has asked for no pecuniary aid from either of those governments, as the association with which he is connected are confident of making profit out of the work, besides reimbursing themselves for their outlay of capital and interest, by the time that the tunnel is completed.

But the gradients contemplated were such as could not be surmounted by any locomotive engine working with a load, on the ordinary system of trusting to its weight for adhesion between its wheels

and the rails; and it was considered that the best method of obtaining extra adhesion would be by the revival of a system long since patented, but never carried out, of adding a third rail between the ordinary bearing rails, to be acted upon by horizontal driving wheels on the engine. A locomotive engine was accordingly constructed, from one of a number of designs which have been patented and described by Mr. Fell, with two pairs of horizontal, as well as two pairs of vertical driving wheels, and an experimental line 800 yards long was laid down in Derbyshire, on the Cromford and High Peak Railway, with the permission and assistance of the London and North Western Railway Company. The gauge was 3′ 7½″, and there were 180 yards of straight line on a gradient of 1 in 13·5, and 150 yards of curves, with a radii of 2½ and 3½ chains, on a gradient of 1 in 12. The third rail upon this line, to be clipped between the horizontal driving wheels of the engine, was laid on its side 7½ inches above the other rails. In the course of a series of experiments, carried on from September, 1863, to February, 1864, the first engine that was constructed, working up to a pressure of 120 lbs. to the square inch, never failed, as I am informed, to take a load of 24 tons up the above inclines and around the above curves, and its maximum load was 30 tons. The outer cylinders, working on the four vertical wheels, which carried 16 tons when the engine was fully loaded, could only draw up, besides the weight of the engine, a loaded wagon weighing 7 tons; while the inside cylinders, acting on the horizontal wheels, which pressed with 12 tons against the middle rail, enabled the engine to take up 24 tons on the same day, and under the same conditions. The inside cylinders alone were able to carry up the engine itself round the curves, and they exhibited the power of taking up altogether 17 tons, as against 23 tons for the outside cylinders, which were nearly in proportion to the pressure and weight upon the horizontal and vertical wheels respectively. The experiments on the High Peak Railway were so successful that it was determined, with the permission of, and for the satisfaction of, the French government, to repeat them on a larger scale on the slopes of the Mont Cenis; the Italian government having undertaken to grant a concession to the promoters for the south side of the mountain, conditionally on a concession being obtained from the French government for the other side; and the French government having promised their concession, after some correspondence and delay, on the condition of the practicability of the scheme being demonstrated.

The experimental line which has now been constructed on the Mont Cenis, is situated between Lanslebourg and the summit, commencing at an elevation of 1622 metres, and terminating at an elevation of 1773 metres (or 5815 English feet) above the sea. It is nearly two kilometres, or a mile and a quarter, in length, and rises for the whole of that distance with a mean gradient of 1 in 13, the maximum gradient being 1 in 12. It passes round a sharp corner, joining two of the zigzags of ascent, on a curve of 40 metres, or about 2 chains' radius, and, except at this point, it is laid on the outside of the road, occupying

a width of 3½ to 4 metres, and leaving 5 metres and upwards clear for the road traffic.

The portion of the road which remains appears to be quite sufficient for the circulation of the existing traffic. The diligences and other conveyances traverse the mountain with no more difficulty than before, and with the additional protection of the railway fence between the road and the precipice. Less inconvenience has been experienced than was anticipated from working the locomotive engines so near to the public road; and as the same horses and mules are, for the most part, employed upon the mountain, they will become more and more accustomed to the noise of the engines and trains. During three months of working, no accident appears to have occurred. The traffic on the road will, of course, be comparatively inconsiderable after the opening of the railway, and there can be no doubt that the portion of the road remaining for it will then be amply sufficient for all purposes.

This experimental line has been purposely constructed on the most difficult portion of the road on which it is proposed to leave the railway without covering, and it was well tested as to the difficulties arising from snow during very severe weather, in the early part of the present year. The result could hardly have been expected. Better adhesion was obtained on the rails in the winter than can be looked for in the summer season. The snow, when removed from the rails in hard weather, left them dry and in good condition, while the peculiar dust of the roads, especially when mixed with water, renders them comparatively greasy or slippery.

This line is laid on a gauge of 1·10 metre, (or 3′ 7⅜″,) with rails borrowed from the Victor Emanuel Railway Company, of the I section, weighing about 75 lbs. to the lineal yard. The bearing rails are fished at the joints, and are supported in cast iron chairs, which are spiked, in the ordinary way, to transverse wooden sleepers, 3 feet apart. The only peculiarity (beside the steep gradients and sharp curves) consists in the addition of a middle rail of the same section, which is led on its side between the other two, and at an elevation (to its centre) of 7½ inches above them. This rail is supported partly on cast and partly on wrought iron chairs, weighing 20 lbs. each at the joints, and 16 lbs. each in the intermediate spaces.

These chairs are now 6 feet apart on the straight line, and from 2 to 3 feet apart on the curves, and the joints of the middle rails are not yet fished. But it is intended to add fish plates immediately to the joints of these rails, and, when the line is laid permanently, to place the chairs 3 feet apart on the straight line, and 1 foot 6 inches apart on the curves, besides securing them to the longitudinal timbers on which they rest by means of through bolts. The longitudinal timbers are 8 inches deep by 12 inches wide, and they are spiked to the transverse sleepers. They will be more securely affixed to them in the permanent road.

The above rails are unfavorable for use as intermediate rails, because the horizontal driving wheels of the engines only bite upon projecting parts of the squared edges of their section; and they are not of

the best quality for affording adhesion; but it was an advantage to be able to procure them in the country, and it may be considered that the rails which will be specially supplied for the permanent line will, at all events, not be less efficacious.

The whole line from St. Michel to Susa will be on average gradients (supposing the culminating point in the middle) of 1 in 25·6. The steepest gradient will be 1 in 12, and a middle rail will be added to the permanent way for all gradients steeper than 1 in 25.

Out of 1960 metres on the experimental line, there are 850 metres of curves, in 450 of which the radius of curvature varies from 84 to 40 metres, while in the remaining 400, the radius measures 100 or more metres. The proportion of curves on the whole line between St. Michel and Susa will be much less; and Mr. Fell proposes, by a happy idea, to modify the gradients on the sharper curves, and to make the gradients on the straight portions of the line contiguous to them more abrupt, though not steeper than 1 in 12. The extra resistance that would otherwise be afforded, in consequence of the friction of the engine and vehicles in passing round the worst curves, will thus be partly avoided, and the tractional resistances over the different parts of the line will be more nearly balanced, because the sharpest curves and the steepest gradient will not occur any where at the same point.

There will be ten level crossings of the road, and six of them on gradients steeper than 1 in 25. The middle rail will be left out at the point of crossing in some of these cases, and will probably be passed by ramps (for animals and vehicles using the road) in others.

The covered ways on different parts of the mountain will extend, altogether, over from 12 to 15 kilometres, (7½ to 9⅓ English miles,) but the latter amount has been provided for. They will be of three descriptions, comprising a wooden roof and sides for, say, 5 kilometres, to keep off light falling snow; a structure of wood, strengthened by iron, for 7 kilometres, as a protection where the snow drifts in deep masses; and a strong masonry arch, for 3 kilometres, in passing the various runs of the avalanches.

There are no exact records of the amount of snow that falls upon the Mont Cenis, but it appears that the cost of clearing it sufficiently to keep the road open for traffic is at present about 12,000 francs annually, as against 31,900 francs on the average for the St. Gothard. The cost of clearing it for the use of the railway, and the difficulties which it would occasion to railway traffic would be small, compared with its present cost and the difficulties of the road traffic, for several reasons. In the first place, the railway would be under cover in those parts of the mountain where the snow would occasion the greatest risk and inconvenience. (2.) The railway would generally, when not under cover, be on the outer side of the road. (3.) The locomotive engines would be available for working the snow ploughs, when fresh falls of snow necessitated their use. The cost of clearing snow from the railway on the Semmering incline is given at 200 francs per kilometre per annum.

The two locomotive engines now on the Mont Cenis have been de-

signed with a special regard for three objects. 1. To develope a maximum of power with a minimum of weight, so as to leave as great a surplus as possible for conveying traffic on steep gradients. 2. To afford extra adhesion, independently of their weight, by means of horizontal wheels pressed by springs behind the axle boxes against an intermediate rail. 3. To work at moderate speeds and round very sharp curves. No. 1 engine weighs 14 tons 10 cwt. when loaded with coke and water. Its boiler is 7′ 9½″ long, and 2′ 9″ in diameter, and it contains 100 tubes of 1½″ external diameter. It has a heating surface of 420 square feet, and a grate area of 6′ 6″. It is provided with four cylinders, two outside cylinders 11¾″ in diameter, with a stroke of 18″, for working four coupled vertical wheels 2′ 3″ in diameter, with a wheel base 5′ 3″, and the two inside cylinders 11″ in diameter, with a stroke of 10 inches, for working four horizontal coupled wheels 1′ 4″ in diameter, with a wheel base of 1′ 7″. It has now a pressure of 16 tons on the horizontal wheels, 4 tons more than was at first applied to them, and about the same weight as is carried from the weight of the engine of the vertical wheels. Guide wheels have also been added to the trailing end of the engine to act upon the middle rail.

This engine labors under serious disadvantages, inasmuch as its machinery is too much crowded together for convenience in readjustment or repair; its boiler power is not sufficient for working the fast traffic of the Mont Cenis, and the oil from its machinery falls upon the horizontal wheels, and deprives them, to some extent, of their power of adhesion. But it has, nevertheless, gone far to prove the principle which it was to test or establish; and it is, considering the novelty of the undertaking, a surprising success.

In the course of two days, I took six trips with this engine, up and down the experimental line, carrying each time a load of 16 tons, in three wagons, including the weight of the wagons, and it performed in the ascent 1800 metres in 8⅛ minutes, with a loss of 14 lbs. of steam, and of 5½ inches of water in the gauge glass, at steam pressures varying between 92 and 125 lbs. to the square inch in the boiler as the average of all those experiments.

The speed attained was in every case greater than that which it is proposed to run with the same load with these express trains; and the average speed as above given was at the rate of 13¼ kilometres (or 8¼ English miles) per hour, instead of 12 kilometres (or 7½ English miles) per hour which is the highest running speed allowed in the programme given to the French government for this part of the line. The weather was fine and calm, and the bearing rails were in first-rate order, but the middle rail as well as the horizontal wheels were oily, and therefore in a condition very unfavorable for good adhesion.

The following calculation shows the average work which was performed by No. 1 engine in the course of these experiments. Omitting in the first instance the extra resistance from sharp curves and neglecting that from the atmosphere, we have the

Resistance from gravity, ... $= \frac{32 \times 2240}{13} = 5{,}514$

Friction of bearing engine (outside cylinders), . . = $16 \times 20 =$ 320
Friction of pressure engine (inside cylinders), . . = $16 \times 20 =$ 320
Friction of train, ... = $16 \times 10 =$ 160

And the tractive force exerted, ... = 6,314 lbs.

1800 metres ÷ 8½ minutes = 5,906 feet ÷ 8½ minutes = 727 ft. per minute.

And $\frac{6{,}314 \text{ lbs.} \times 727 \text{ ft. per minute}}{33{,}000 \text{ ft. pounds per minute}}$, ... = 139 H.P.,

as against the same load at 12 kilometres per hour, . . = 125 H.P.
Adding 10 per cent. for extra resistance on sharp curves in each case,
139 + 10 per cent. = 153 horse power at 1800 metres in 8½ minutes.
125 + 10 " = 137·5 " 1800 " 9 "

15·5 excess of horse power above what was required.

The consumption of fuel during these experiments is hardly worth recording, because it was impossible to distinguish between what was burnt while the engine was standing, and that which directly contributed to the power exerted. But the engine having been under steam about 3 hours the first day and 3½ hours on the second day, there was consumed altogether, as nearly as I could ascertain, 583 lbs. and 653 lbs. of mixed fuel on those days respectively. Of the above time, about 97 or 98 minutes were occupied in running 15 miles during the experiments up and down the line on both days.

This engine has run upwards of 100 miles altogether in ballasting and conveying materials upon the experimental line, carrying loads of from 16 to 20 tons, without accident or difficulty.

No. 2 engine, intended specially for working the traffic of the Mont Cenis, is partly of steel. Its net weight is 13 tons, and its greatest weight, when fully loaded with fuel and water, 16 tons 17 cwt., giving a mean weight of 16 tons, which will be brought up, when certain parts have been strengthened as contemplated, to a maximum weight of 17 tons 2 cwt., and a mean weight of 16 tons 4 cwt. The extra machinery for the horizontal wheels weighs, however, only 2 tons 13 cwt.

The boiler is 8′ 4½″ long, and 3′ 2″ in diameter, and contains 158 tubes of 1½″ external diameter. The fire-box and tubes contain altogether 600 superficial feet of heating surface, and there are ten feet of fire-grate area. There are only two cylinders, with a diameter of 15″ and a stroke of 16″, which work both the four coupled horizontal, and the four coupled vertical wheels, which are all 27″ in diameter. The wheel base of the vertical wheels is 6′ 10″, and that of the horizontal wheels 2′ 4″. The maximum pressure in the boiler is 120 lbs., and the effective pressure on the piston is 75 lbs. to the square inch.

Besides possessing a greater amount of boiler power, this engine travels more steadily than No. 1; its machinery is more easily attended to, and the pressure upon its horizontal wheels can be regulated by the engine driver at pleasure from the foot plate. This pressure is applied through an iron rod connected by means of right and left handed screws with a beam on each side of the middle rail, and these beams act upon

volute springs which press the horizontal wheels against that rail. The pressure employed during the experiments was 2½ tons on each horizontal wheel, or 10 tons altogether; but the pressure actually provided for, and which may, when necessary, be employed, is 6 tons upon each, or 24 tons upon the four horizontal wheels.

The vertical wheels are worked indirectly by piston rods from the front, and the horizontal wheels directly by piston rods from the back of the cylinders. The motions connected with the horizontal wheels appeared to be working perfectly well; but unfortunately some of the parts in front of the cylinder connected with the vertical wheels required strengthening, and it was not desirable, for fear of injury that would cause further delay, to test the engine much or heavily while I was upon the mountain, or until the new parts, which are under construction, had been received from England. I was able, however, to take it up 1800 metres on the experimental line with the same load as before, of 16 tons in three wagons in 6¼ minutes, or at a speed of 17⅓ kilometres per hour, as against 12 kilometres per hour which it is proposed to run with the express trains. The steam pressure in the boiler fell from 112 to 102½, and 3 inches of water were lost in the gauge glass, the feed having been turned on during the later period only of this experiment. No. 2 engine (whose frictional resistance is 120 lbs. less than No. 1 engine, when only 10 tons of pressure are employed on the horizontal wheels) exerted, in this instance, omitting the extra resistance from curves, 177 horse power, or adding 10 per cent. for the resistance from curves, 195 horse power, or more than 12 horse power to each ton of its own weight, and nearly 60 horse power in excess of what was required to take the same load up the same gradients and curves at 12 kilometres per hour, as proposed in the programme.

Allowing 4 feet of heating surface to each horse power, this engine ought to be capable of maintaining 150 horse power, or 45 horse power less than it exerted for a comparatively short distance in the above experiments, but considerably more than it will be necessary to exert to carry out the programme. And, indeed, a light train carrying despatches and 50 passengers, and drawn by one engine, would perform the journey without difficulty in four hours, instead of four hours and a half, from St. Michel to Susa.

I observed on the following day, that 40 lbs. of steam pressure in the boiler, or one-third of the maximum pressure employed, was sufficient to move the engine alone up a gradient of 1 in 12½; and the friction of carriages or wagons being proportionately much less than that of an engine, the same engine ought, *a fortiori*, to be able to move a gross load of three times its own weight, or 48 tons, at its greatest working pressure, up the same gradient.

The only passenger carriage that has yet been constructed is 6′ 4″ wide, by 12 feet long, by 6 feet high inside. It has a passage down the middle, and six seats on each side, on which passengers sit facing one another. The wheels are 2′ 3″ in diameter, and it is intended that all carriage and wagon wheels shall run loose on one side of the axle. Every vehicle will be provided with a break of the ordi-

nary description, and a large proportion also with breaks acting on the middle rail.

The road traffic between St. Michel and Susa appears from the returns of the Victor Emanuel Railway to show an average increase of rather more than 10 per cent. per annum during the last four years. Estimating the traffic to increase in the same ratio only after the opening of the railway, the total revenue in seven years, from 1867 to 1873, would be upwards of 27,000,000 francs; and it is considered that such a revenue would leave, at the end of that time, a clear profit of several millions of francs, after deducting all charges, and after paying interest upon, and paying off, the total bond and share capital of 8,000,000 francs. The value of the railway and rolling stock would also be, at the end of that time, to the credit of the company. But it cannot be doubted that the passenger traffic would increase in a much greater ratio after the opening of the railway, in consequence of the great saving of time, and the greater comfort and convenience in the passage of the mountain; or that there would be, not only an increase in the goods traffic, but also a prospect of developing a traffic of cheaper goods and minerals which do not, as yet, pass over the mountain. And the projectors have, further, a reasonable hope of carrying the Indian mail, on the ground that they will be able to save 38 hours of time in its transmission between England and Egypt.

To provide for the carriage of 132 passengers and 88 tons of goods daily, they propose to run three trains each way, namely, one train carrying 40 passengers and their luggage, weighing, exclusive of the engine, 16 tons, and traveling at a mean speed of 18 kilometres per hour for the 77 kilometres between St. Michel and Susa; a second train carrying 26 passengers and 20 tons of goods, and weighing 40 tons, at an average speed of 12 to 14 kilometres per hour; and a third train, carrying 24 tons of goods, and weighing 48 tons, at an average speed of 10 kilometres per hour. The first of these trains they propose to take up the mountain by one engine, and the second and third by two engines each.

The relative distances by the Mont Cenis route from Paris to Turin and Genoa, and the route by Marseilles to those places, may be thus stated: In proceeding from Paris the two routes diverge from the common point of Macon, and the distances are

	By Marseilles, English Miles.	By Mont Cenis, English Miles.
Macon to Genoa, . . .	559	326
Macon to Turin, . . .	659	226

showing a saving in favor of the Mont Cenis route of 233 miles to Genoa and 443 to Turin.

The time that would be occupied in the journey between this country and Egypt, *via* Paris, may be estimated for the route by Marseilles, and the route by Mont Cenis and Brindisi (the Italian railways having recently been opened for traffic to that port) respectively as follows:

For the Marseilles route:				
Paris to Marseilles, 864 kilometres, at 54 per hour,				16 hours.
Marseilles to Alexandria, 1460 nautical miles, at 10 per hour, with 6 hours' delay at Malta,				152 "
Total,				168 "
For the Brindisi route, by Mont Cenis and Brindisi:				
Paris to Macon,	441 kilometres	at 54	per hour,	8¼ hours.
Macon to St. Michel,	237 "	40	"	6 "
St. Michel to Susa,	77 "	18	"	4½ "
Susa to Brindisi,	1159 "	40	"	29 "
Brindisi to Alexandria,	822 nautical miles,	10	"	82½ "
Total,				130 "

showing a saving in favor of the Mont Cenis and Brindisi route of 38 hours. This would be of importance in facilitating the communication between this country and India, and in the transmission of the Indian mail, though it is to be observed that there would necessarily be a change of vehicles at St. Michel and Susa.

The results of this experiment are of great importance to the future of railway construction in mountainous countries, as will be seen from the following observations:

Whenever it becomes necessary to cross a chain of mountains by a line of railway, the question arises as to whether it will be more economical to pass over the summit, or to make a tunnel of greater or less length. The cost of construction, and of working the estimated traffic, being duly considered, it is necessary to determine what elevation should be reached, and what length, if any, of tunnel should be formed, according to the circumstances of each case, and the most important element in the calculation is the limit up to which steep gradients may be safely and economically worked.

Mr. Fell has shown practically that gradients of 1 in 12 to 1 in 15 may, by a system of horizontal driving wheels acting upon a middle rail, be substituted for 1 in 25 to 1 in 30, which have hitherto been practicable, and that sharper curves may also by this system be more safely worked. He has proved, in other words, that a railway may be constructed over a given summit of half the length that would otherwise have been necessary, and at less than two-thirds of the cost; because, although the permanent way would be more expensive, averaging, say, £3000 instead of £1800 to £2000 a mile, yet, by the adoption of steeper gradients and sharper curves at critical points, cuttings or embankments may be reduced or avoided, and the works generally be more cheaply laid out. And the cost of working and maintenance would, considering the same elevation to be reached, be cheapened, as well as the cost of construction. There would be half the length of line to maintain, and the speed of the trains would be reduced. Only half the speed would, indeed, be required to reach the summit in the same time, and the same (gross) loads might be taken up by the same expenditure of power at that speed so reduced to one-half, while the adhesion of the locomotive engines being doubled with the addition of no more than a sixth to their weight, an important saving would thus

be effected in the dead weights of the trains. The cost of traction, which must in taking a given (gross) load to a given height be nearly the same, would not increase so much in consequence of the saving of dead weight thus effected; and other expenses would decrease to some extent in proportion to the wear and tear and resistances incidental to a higher, but avoided at a lower, velocity.

A summit line may for these reasons be made with greater facility in less time and to greater advantage than heretofore, and it will be interesting, taking the Mont Cenis as an example, to compare the cost of the tunnel line now in course of construction under that mountain with a permanent line, which might be made over it. The comparison is not made here with a view to that particular case, because it may now be taken for granted that the permanent tunnel line will be completed within a certain number of years, and because the summit line projected by Messrs. Brassey & Co. is only put forward as a temporary line, to be used pending the opening of the permanent line from St. Michel to Susa, but as being important with reference to other mountain passes in the Alps and elsewhere.

The temporary line is estimated (by Mr. Brunlees, C.E., to cost 8,000,000 francs, or £320,000, or about £6720 per mile, whereas the tunnel line will probably cost, including interest at 6 per cent. during construction, 135,000,000 of francs, or £5,400,000, or £128,500 per mile, the latter being 68 kilometres (42 miles) in length, with a maximum gradient of 1 in 28, and a gradient through half of the grand tunnel of 1 in 35½, and an average gradient for the whole of 1 in 46; and the former being 77 kilometres (about 48 miles) in length, with a maximum gradient of 1 in 12, and an extra elevation of 2520 feet, and the time occupied between St. Michel and Susa would, including stoppages, be about 3 hours by the tunnel and 4½ hours by the summit.

The cost of a permanent and independent summit line with a wider gauge and better curves, may be taken at £20,000 a mile, or nearly three times as much as the above temporary line, and the extra cost of working over a super-elevation of 2520 feet, based upon a traffic ten times as great as that which is carried at present over the Mont Cenis, and upon the average cost of traction (0·25 of a franc or 2½*d.* per horse power per hour) upon the Semmering and Giovi inclines, capitalized at 6 per cent., at £13,000 per mile. These two sums added together amount to £33,000 per mile, or rather more than one-fourth of £128,500 per mile set down above for the tunnel line.

This estimate would, of course, be materially modified by local circumstances, but it is as good an illustration as can be given at present of the advantages that may be derived, in cases in which stationary engines and inclines worked by ropes are not appropriate, from constructing railways on steeper gradients than have hitherto been considered practicable, in the manner which Mr. Fell has now shown to be available.

As the results of his observations and experiments, Captain Tyler reports in conclusion, that this scheme for crossing the Mont Cenis is, in his opinion, practicable, both mechanically and commercially, and

that the passage of the mountain may thus be effected, not only with greater speed, certainty, and convenience, but also with greater safety than under the present arrangements. Few would, in the first instance, either contemplate or witness experiments upon such steep gradients, and round such sharp curves on the mountain side, without a feeling that much extra risk must be incurred, and that the consequences of a fractured coupling, or a broken tire, or a vehicle leaving the rails, would on such a line be considerably aggravated.

But there is an element of safety in this system of locomotive working which no other railway possesses. The middle rail not only serves to enable the engine to surmount and to draw its train up these gradients, but it also affords a means of employing any required amount of extra break power for checking the speed, or for stopping any detached vehicles during the descent; and it further acts, by the use of horizontal guiding wheels on the different vehicles, as a most perfect safeguard, to prevent engines, carriages, or wagons from leaving the rails, in consequence either of defects in the bearing rails or of failure in any part of the rolling stock. The safest portions of the proposed railway ought, indeed, under proper management, to be those on which, the gradients being steeper than 1 in 25, the middle rail will be employed.

There is no difficulty in so applying and securing that middle rail, and making it virtually one continuous bar, as to preclude the possibility of accident from its weakness or from the failure of its fastenings, and the only question to my mind is, whether it would not be desirable still further to extend its application to gradients less steep than 1 in 25. It would apparently be advantageous to do so, not only for the sake of obtaining increased adhesion with less proportional weight, and, therefore, economical traction, but also with a view to greater security, especially on curved portions of the line.

After going with Mr. Fell through the different calculations and considerations which are involved in the undertaking, Captain Tyler finds that he has, during three years of labor, treated them with the utmost care and caution, and has no doubt of his being able (if Mr. Fell obtains, as he hopes to do in the course of a few weeks, the necessary authority from the French government) to carry it forward to a successful issue. It is anticipated that in the course of the summer of 1866, in time for the autumnal stream of travelers into Italy, Mont Cenis will be traversed by rail in 4½ hours, or even less, from St. Michel to Susa, now a tedious diligence journey, on wheels or sledge, according to season, lasting more than double that time.

On Marine Engines from 1851 *to the Present Time.*

By N. P. Burgh, Esq., Engineer.

From the Journal of the Society of Arts, No. 643.

(Continued from page 242.)

Having alluded to the principal working details, I will now lay before you a description of the mode of condensation—past and present. It

is well known that the principle of condensation is to convert the steam into its original state. The contact of the cool fluid, in the shape of water, accomplishes this in the ordinary condenser, and cooling surfaces in the surface condenser.

In the days of the introduction of side-lever engines, the arrangement of the condenser and air pump was faulty; in some cases the foot-valves were almost inaccessible. Not many years ago, being on board a steamship fitted with old side-lever engines, which were then undergoing repair, I noticed a rope and block-tackle over near the condenser. On inquiring of the engineer how he progressed, the answer was, "I am just going to sling one of the men with this tackle by the heels, to inspect the foot-valves; and that," said he, "is no foolish job." On further examining the engines, I found that an upside down attitude was required, and indeed the only one allowed for the inspection of the valves in question. Happily now, however, such an inconvenient arrangement is of rare occurrence. We also find the side-lever engine is being superseded by that of the oscillating type.

The arrangement of the ordinary condenser and air pump for oscillating paddle engines is generally as follows: The condenser is situated between and below the trunnions of the two cylinders; the air pumps are at an angle, with trunks and connecting rods of the ordinary kind; the foot-valves are at the bottom of the barrel of the pump; the piston has valves in it, and the discharge valve, when not at the the top of the pump barrel, is at its side. Now, the principal defects in this arrangement are in the position of the valve and condenser. When the foot-valves are directly underneath the pump's piston, it is obvious that an almost entire disconnexion must be made to inspect them. Also, in the case of the piston valves requiring inspection, the pump cover must be removed, and to attain this the gland packing has to be slackened, and the connecting rod disengaged. Now, to avoid these evils, doors might be introduced, but with these disadvantages—increased height or length of the air pump passages, and a body of water always above and below the piston, which is undoubtedly what any right-thinking engineer would disapprove of, it being clearly understood that an air pump will produce a better vacuum when the piston thoroughly discharges the contents between the foot and delivery valves at each stroke.

Having thus pointed out the existing evils of the ordinary arrangement, it will not be deemed out of place to introduce a remedy. The condenser at the side of or below the pump is in one of the worst positions that can be conceived; the idea of allowing the condensed steam to fall only to be raised again, seems, on consideration, to be foreign to the ideas of our talented engineers. It is well known that, in ordinary arrangements, the condenser is always in the position alluded to; steam, even of a low pressure, is larger in volume, but not as dense and heavy as water; it is also more elastic, hence it will more readily ascend. This, then, being clearly understood, it is not unwise or impracticable to assume, that if the condenser were on the top of the air pump, instead of at its side or bottom, a better vacuum would be main-

tained. I beg to offer a description of an arrangement of condenser and position of the valves, both for correct action and accessibility. It will be understood that the condenser in this case is over the air pump; the suction valves are inverted, consequently the weight of the water assists the action of the piston in causing a vacuum. The exhaust steam from the cylinders rushes up the exhaust pipe, and enters on the top of the condenser. The water in the air pump is discharged through the delivery valve, at the top of the pump, and from thence through the delivery valve at the ship's side. A door is secured opposite the delivery valve, and doors are provided on each side below the bottom of the condenser, for the double purpose of inspecting the suction valves and the air pump piston.

This arrangement of condenser and air pump will occupy as little room as those of the ordinary kind, with the advantage of accessibility to all the working parts without disarrangement. It may be argued that the stuffing box, being in a recess when used for guides, would be troublesome to keep tight or repack, but if oil be always kept in the recess, so as to entirely cover the gland, it would tend to lessen the liability of leakage; the nuts of the gland and bolts could be adjusted by a box spanner, or the bolts prolonged to the top of the condenser. In cases where the depth of the ship would admit, the recess could be dispensed with; trunks are not proposed for this arrangement, as their diameters would be necessarily increased, owing to the length required to pass through the condenser, unless a recess were resorted to, as now proposed.

The next portion of the subject now before us is the ordinary condenser for screw engines. The action of the air pump in this case is usually horizontal; consequently the valves are at right angles to the pump. To describe each arrangement of condenser and air pump that have come under the writer's notice would occupy too much time; consequently a brief mention of two or three examples on this occasion will be deemed sufficient. For direct acting and trunk engines, with the cylinders secured together, or side by side, the condensers were between and, in some instances, in front or at the sides of the air pump. The foot and discharge valves were directly over each other, the former under the pump at each end, the condensed water or steam being drawn through the foot valves and forced through those above. In another instance the foot and delivery valves were extended the entire length of the air pump and passages, the position of the valves over and under being as before, and the condenser being between the air pumps. For return connecting rod engines, the condenser and air pumps are subject to great disadvantages. In order to obtain a passably good arrangement, and, at the same time, occupy a moderate space in proportion to those last mentioned, the condenser, &c., have to be shaped to suit the purpose required. It must be perfectly understood that when the piston rods are beyond the crank shaft (as in the examples now in question) there is a certain amount of space required for the piston rods and guides of the crosshead, or guide block, whichever may be used. It is also clear that accessibility to all the valves

without disarrangement should be attained. To illustrate these desiderata the following examples will be sufficient for the present purpose: In one instance the condenser is partially between the cylinders, and extending beyond the crank shaft; the air pumps are at the side of the condenser; the suction valves extend the length of the air pump; and the discharge valves are between each pump, the pump and the valves being beyond the crank shaft.

The next example is as follows: The condenser and its appendages are entirely beyond the crank shaft. The air pumps are at the extremity or sides, and near the bottom of the condenser. The foot and discharge valves extend the entire length, and are arranged over and under the pumps in the usual form. The guides for the piston rods are between the upper portion of the condenser and that of the discharge chamber.

Having disposed of the principal arrangements of air pumps and condensers as formerly constructed, allusion will now be made to those of recent improvement and practice. As before stated, a better vacuum can be attained when the condenser is over the air pump instead of at its side. For direct acting engines there are two arrangements specially worthy of notice. 1. The air pumps are worked by the steam pistons between the cranks as near as the base lines of the engine as the periphery of the circles will admit, the condenser being one chamber, directly over the air pumps. The suction valves are inverted in the bottom of the condenser so as to effectually drain the same. The discharge chamber extends the entire length on each side and back end of the condenser, the valves being nearly in the same line as those for the suction, but reverse in action. The next example is the same as the last principle, although different in arrangement. The air pumps are situated as in the last example, but the condensers are separate, one to each engine, over and on each side of the air pump. The suction valves are inverted in the bottom of each condenser to obtain the advantage before alluded to, the discharge chamber and valves being central or between each condenser, and directly over and between the air pumps. It may now be argued, that if the two examples last mentioned are perfect in action and arrangement, what is the cause of the diversity? The answer to this is, Diversity of idea. Engineers, as a rule, are averse to the act of copying from each other. No sentence grates more harshly on the ear of a scientific man than the words, "Where did you copy this?" or is more repugnant to his dignity.

Having referred to the improvements in the arrangement of condensers, &c., for direct acting engines, attention will now be given to those adopted for double piston rod engines. It must be borne in mind that for this class of engine the prolongation of the piston rods beyond the crank shaft greatly deteriorates the arrangement of the air pumps and condensers, in relation to the space occupied by those for single piston rod engines. In the examples now given, the air pumps are worked by the steam piston, and as near the base line as possible. The condensers are separately arranged outside the guides of the piston rods

of each engine; the suction valves are inverted above the top of the air pump, as in the last examples; the discharge chamber is between the air pumps and the valves, on the same level as those for the suction. It will thus be understood that both suction and delivery are at the side, over and extending the length of each air pump, instead of being directly over them, as in some cases.

The next example worthy of notice is arranged as follows: The condensers and their appendages are beyond or outside the guides of each engine, the air pumps deriving their motion as in the previous examples, and are as near the base line as possible, so situated as to clear the guides. Partially over and beyond the side of each air pump are the discharge valves, above which is the discharge chamber; over this, and at the side of the same, is the condenser with the suction valves inverted.

I will now allude to the system of condensation known as surface condensation. Mr. Hall, in days of yore, introduced the tubular arrangement with great advantage. Engineers at that time were slow in appreciating the then presumed gain, and it is only lately that we have seen the surface condenser universally adopted by the powers that be. To condense steam properly is undoubtedly to reduce it to its natural or original state. Now, in the ordinary condenser we bring water into actual contact with the steam to condense it. Surface condensers are to be recommended, particularly for one reason, viz: the production of distilled water for the feed of the boilers. The arrangement of the tubes in surface condensers entails practical difficulties as to the position most suitable, whether they be inserted transversely, perpendicularly, or longitudinally of the hull of the ship, renewal of the tubes being often required (sometimes while at sea) from corrosion.

The means adopted to render the connexion of the tubes in the plate air-tight are numerous. The usual mode now is—india rubber rings recessed in the plates encircling each tube—compression being obtained by a nut for perpendicular tubes, and by the vacuum in the condenser for those of horizontal positions; this is simple and efficacious, and at the same time economical. It must here be remarked, however, that compression of the india rubber by vacuum can only be attained when the steam is condensed by the external surface of the tubes or within the plates. The circulation of the water is either through or surrounding the tubes, and is produced by pumps with plunger piston or centrifugal action. The position of the piston pumps is horizontal, motion being derived either from the steam piston or piston rod. The centrifugal pump requires a separate engine, or spur gearing, &c., from the crank shaft to give the required velocity.

The values of the two arrangements now used for the condensation of the steam are about equal. In the case of the water surrounding the tubes, the steam passes through the same, and in the case of the steam surrounding the tubes the position of the water is reversed.

It is obvious that where internal condensation is effected, a great number of tubes are required, in relation to those of the external system—the inner surface of the tube being less than that of the outer.

The advantage gained by the steam entering the tubes may be said to be—access for cleaning without disarrangement. Injection, or ordinary condensers, are more generally used than those of the surface kind, on account of economy in the outlay of capital at the commencement.

The injection valves for ordinary condensers are generally of the solid or gridiron type, the latter to reduce the stroke to open and close. The pipe for the dispersion of the water is usually a tube, with apertures, of an elongated or circular form. An improvement has lately been made in these pipes, by contracting the area for one-half the length, thus equalizing the diffusion of the water throughout.

The next valve necessary for the condenser is the shifting valve, which is a single disk of gun metal, with a slight spiral spring at its back, or upper part. A screwed spindle is universally used to prevent the valve from rising, after the water and air in the condenser has been blown out previously to starting the engines. It might be deemed neglectful if I were not to make allusion to the bilge injection valve or cock, whichever may be used. This valve, as well known, is only required in cases of necessity, such as leakages, or disarrangement of the bilge or donkey pumps. I would beg to suggest that the bilge water should not be allowed to enter the condenser, on account of the generally impure state of the bilges. A valve and box might be arranged at the end of the air pump for this purpose.

The portions of the marine engine next for exemplification are the feed and bilge pumps. The position of these is so arranged that a free access can be obtained to the valves and surrounding parts without disarrangement. Some makers prefer to work the feed and bilge pumps in a line with each other, with one rod and plunger direct from the steam piston. Other firms secure the pumps side by side to the discharge water pipe of the condenser, each plunger being connected to the piston rods crosshead; this latter improvement is more general than the former. In the case of hollow plunger or trunk air pumps, those for the feed and bilge are on each side of the air pump, and secured by nuts or keys. Before terminating this portion of the subject, it will be well to add that the valves for the air, feed, and bilge pumps are now universally disks of india rubber, instead of the gun metal spindle valves.

It will have been observed that no allusion has yet been made to the arrangement of combined high and low pressure engines. For the purpose of comparison I will allude only to those arrangements in common use. The position of the low pressure cylinders is side by side, as for those of the ordinary kind; in some cases annular cylinders are used, viz: the high pressure cylinder within that for the low pressure. Another arrangement is the high pressure cylinder on the top of that for the low pressure. A third arrangement has the smaller cylinder at the back end of the larger. A fourth example consists of two high pressure cylinders in front of one for low pressure, the former acting as guides for the piston rod. The means adopted for imparting the motion of the piston to the cranks are of the ordinary arrangements

already described, with the exception of the necessary extra piston rods and stuffing boxes.

Having alluded to the different engines and their details, past and present, adapted for the single screw, I will now call attention to a notice of arrangement of engines as at present used for the twin or double screw system. It must here be mentioned that the class of engines now under notice have precisely the same duty to perform as those before described; consequently, if I pass over the major portion of the detail it is to avoid repetition.

The arrangement of the engines is usually separate for each screw. The type of engine generally adopted at present is direct acting with surface or injection condensers. Single piston rod engines seem to be more in favor than those of the double piston rod return action type, I presume on account of the simplicity of the former. The position of the arrangement in plan is side by side—port and starboard—instead of directly opposite each other; this is owing to the space required for the arrangement adopted, and the small beam of the veessel; but in some cases, engines are arranged opposite each other, with a great reduction of space compared to that of the side system. When the crank shaftings are connected, the steering principle is destroyed, and the twin screw system, so far as regards propulsion, is very little better than the single system.

There is not the least doubt that, as a mode of steerage, the twin system is correct, and for shallow drafts it is advantageous. To suppose the plan to be universally correct for large vessels requires, however, more practical evidence than I at present possess; but of this I am confident, that for small or large vessels, whether for commercial or war purposes, the twin screws, when driven separately, are invaluable for steering. The advantages for war ships are principally the facility for manœuvering when under an engagement. Let it be presumed that the enemy has aimed at a twin screw steamer; by a contrary action of the screws her position can be shifted instantaneously, and the intended evil postponed, if not averted.

I have come to the end of my brief description of the marine engine, and will now allude to the weight of material, cost of marine engines, and the relation of nominal to actual horse power, together with the consumption of fuel. The variation in the weight of marine engines is due to the design and arrangement as much as the material used. Double trunks may be said to be a fair example as to the average weight of marine screw engines. Return connecting rod engines are perhaps the heavier, in comparison to those of the single type, in relation to rods and guides. High and low pressure engines combined are the heaviest of any examples yet given. The materials comprising the different portions of the engines of the present day are of six kinds—first, cast iron, of which is formed the cylinders, pistons, valves, casings, main frames, guides, condensers, &c.; secondly, wrought iron, comprising cranks and shaft, piston and valve rods, links, levers, weigh shafts, bolts, nuts, &c.; thirdly, steel for springs, small pins, &c.; fourthly, gun metal for bearings, guide blocks, bushes, glands, nuts,

&c.; fifthly, copper, for pipes of all kinds required for steam and water; sixthly, india rubber, for valves packing, &c. For the present occasion, in reference to weight, I have selected twelve examples of marine screw engines, each varying in power and design. The examples of arrangement being in pairs, the result has been that 4·334 cwt. per nominal horse power may be taken as the average weight of material, exclusive of boilers, fittings, screw propellor, and alley-shafting. It may here be observed that each maker of marine engines in the present day differs in design and arrangement, consequently the weight of trunk engines by different makers would be unequal. The same may be said for single piston rod engines, as well as for double piston rod return connecting rod engines.

I now come to that portion of this subject which is the crowning question of all, and too often the cause of much controversy in political and commercial circles, viz: what is the cost? My opinion is, that it is perhaps the most difficult query to answer that could be put, and the only reason for its introduction is to preserve myself from presumed neglect in not noticing this important matter. To ascertain correctly which is the cheapest class of engine at present in use, is a problem much too difficult for me to solve; but I will, however, tender such information as I deem reliable.

The price of a marine engine depends entirely on the class of workmanship. Should a roughly-finished engine and boiler be required, with more painted than polished surfaces, the cost will be reduced in comparison to that of the more highly finished. The fittings also greatly regulate the outlay. Some companies pride themselves on this portion of display, others, again, look on it as an unnecessary expense; so, to draw a correct line of comparison would involve the amalgamation of the many ideas in order to give a fair evidence. I feel confident, however, that marine engines, with boilers and fittings complete, can be produced of certain classes, for £70 per horse power nominal, and the same can be reduced to £50 per horse power, each price, of course, being under certain conditions as to terms and workmanship.

Allusion must now be made to the power, &c., of marine engines. Nominal power is a term used particularly for commercial purposes. Each maker has his private rule, hence the difference in dimensions in engines of the same class and power. Actual horse power is defined by the indicator diagram, speed of piston, &c.; the ratio between the nominal and actual power is in some cases low, in others high. The writer has known instances where, the nominal power being 1·0, the actual was 6·0; and in others, nominal 1·0, actual 2·123; the average ratio at present is, nominal 1·0, actual 4·0 to 5·0. With reference to the consumption of fuel, there is a great difference in the evidence. Superheating and surface condensation are slowly making progress, and at the same time reducing the consumption of fuel in ratio to the amount of water evaporated or steam used. The average actual horse power expended per cubic foot of water evaporated is, water being 1·0, actual horse power 2·635 to 4·0, and doubtless in some cases more.

TWIN SCREW PROPULSION.—*Tabular Statement of Ships, Marine Engines, &c., constructed by Messrs. Dudgeon & Blackwell, since* 1851 *to the present date, supplied by the firm.*

Beam of Vessel.	Length.	Depth.	Tonnage	Immersion.	Nominal horse power.	Diameter of cylinder.	Length of stroke.	Kind of Condenser.	Diameter of air pump.	Diameter of screw propeller.	Pitch of screw propeller.	Distance between centres of propellers.
ft. in.	ft. in.	ft. in.	tons.	ft. in.		inches.	inches.		inches.	ft. in.	ft. in.	ft. in.
22 6	150 0	13 0	395	9 0	120	26	21	Injection.	8½	7 0	14 6	8 9
23 0	165 0	13 6	425	"	"	"	"	"	"	7 5	"	"
"	"	"	"	"	"	"	"	"	"	"	"	"
"	"	"	"	"	"	"	"	"	"	"	"	"
34 0	225 0	22 0	1,258	17 0	150	H. 24 L. 50	24	"	12	8 10	16 0	11 8
25 0	175 0	15 0	531	9 6	200	34	21	"	11	8 3	16 0	10 5
23 0	165 6	13 0	425	9 0	120	26	21	"	8½	7 0	14 6	8 9
"	"	"	"	"	"	"	"	"	"	"	"	"
"	"	"	"	"	"	"	"	"	"	"	"	"
"	"	"	"	"	"	"	"	"	"	"	"	"
11 10	57 6	7 0	35	4 10	30	12	11	High pressure.	None.	3 8	7 4	4 6
23 6	200 0	13 4	546	9 6	200	34	21	Injection.	11	8 0	16 0	9 5
15 0	85 0	6 6	91	2 9	30	12	11	High pressure.	None.	3 6	7 4	4 6
"	"	"	"	"	"	"	"	"	"	"	"	"
34 0	265 0	28 0	1,500	16 0	350	H. 31 L. 62	24	Surface.	11	10 6	18 0	12 0
17 0	100 0	6 6	138	3 6	30	12	11	Injection.	5¾	4 0	7 6	5 4
32 0	160 0	13 3	737	10 0	200	34	21	"	11	8 0	16 0	9 5
24 6	200 0	13 4	592	9 6	"	"	"	"	"	"	"	"
28 0	250 0	15 6	972	10 0	300	40	22½	"	13	9 2	17 3	10 9
"	"	"	"	"	"	"	"	"	"	"	"	"
27 0	230 0	14 6	829	9 6	250	37	21	"	12	8 9	16 0	10 0
21 6	190 0	13 0	436	10 0	120	26	21	"	8½	7 0	14 6	8 9

TABULAR STATEMENT *of Marine Engines constructed by Messrs. John Penn & Son, Greenwich, supplied by the firm.*

Screw Engines.

	Minotaur.	Achilles.	Warrior.	Black Prince.	Resistance.
Diameter of cylinder,	104¼	104¼	104¼	104¼	70¾
Length of stroke,	4 ft. 4 in.	4 ft. 0 in.	4 ft. 0 in.	4 ft. 0 in.	3 ft. 6 in.
Revolutions per minute,	—	52½	54¼	51¼	68 to 69
Diameter of screw,	24 ft. 0 in.	24 ft. 0 in.	24 ft. 6 in.	24 ft. 6 in.	18 ft.
Pitch of ditto,	25 ft. 6 in.	25 ft. 6 in.	30 ft. 0 in.	30 ft. 0 in.	21 ft.
Nominal h.p.,	1350	1250	1250	1250	600
Indicated h.p.,	—	5746	5471	5146	2424
Speed of ship,	—	14·25 knots	14·35 knots.	13·31 knots.	11·84 knots.
Date of trial,	—	Dec. 28, 1864.	Oct. 17, 1861.	Aug. 30, 1862.	Sept. 23, 1862.

Paddle-Wheel Engines.

	Exploratore.	Taliah.	Izzeddin.	Victoria.	Prince Imperial.
Diameter of cylinder,	72 in.	72 in.	66 in.	88 in.	52½ in.
Length of stroke,	5 ft. 0 in.	5 ft. 0 in.	5 ft. 0 in.	4 ft. 6 in.	4 ft. 0 in.
Revolutions per minute,	40	39	41½	42	48 to 49
Diameter of axis of wheel,	19 ft. 0 in.	19 ft. 0 in.	17 ft. 6 in.	17 ft. 6 in.	14 ft. 11 in.
Length of floats,	10 ft. 0 in.	10 ft. 0 in.	10 ft. 0 in.	7 ft. 10 in.	8 ft. 0 in.
Depth of ditto,	4 ft. 0 in.	4 ft. 6 in.	3 ft. 10 in.	3 ft. 6 in.	3 ft. 2 in.
Nominal h.p.,	350	350	300	220	180
Indicated h.p.,	2556	2540	2373	1640	1480
Speed of ship,	17·27 knots.	17·74 knots.	16·5 knots.	16·83 knots.	16·3 knots.
Date of trial,	May 6, 1863.	Dec. 28, 1863.	Sept. 19, 1864.	Sept. 3, 1861.	Sept. 28, 1864.

The following is a list of engines constructed by Messrs. Maudslay, Sons & Field for H. M.'s Navy since 1851 to the present date, kindly furnished by Joshua Field, Esq.:

	Horse-power, nominal.
Engines, &c., for 75 Screw Vessels,	Total, 37,570
" 26 Paddle "	" 6,340
" 69 Screw Gunboats,	" 4,260
Total,	48,170

THE FOLLOWING TABLE *gives particulars of some of the principal Marine Engines recently constructed by Messrs. R. Napier & Sons, Glasgow.*

NAMES OF VESSELS.	Paddle or Screw.	Material.	Tonnage. O. B. M.	Kind of Engine.	Number of cylinders.	Diameter of cylinder.	Length of stroke.	Nominal horse power.	Kind of Boilers.	Kind of Propeller.
						inches	ft. in.			
Coromandel, . . .	Screw	Iron	—	Plunger, direct	2	50	2 6	250	Tubular	Common
Gunboat for H. E I. Company,	"	—	—	Horizontal, high pressure	2	18	1 6	80	"	"
Emperor Alexander, .	"	"	—	Plunger, direct	2	60	3 0	350	—	"
Islesman, . . .	"	"	197 $\frac{81}{94}$	Horizontal	2	24 $\frac{1}{8}$	3 0	80	Tubular	"
Victoria, . . .	Paddle	"	144 $\frac{76}{94}$	Oscillating	2	27 $\frac{1}{16}$	3 0	44	"	Radial
Fifeshire, . . .	"	"	—	Inclined	2	36 $\frac{1}{2}$	3 6	82	Lamb's flue	Eccentric
Chevy Chase, . .	"	"	963 $\frac{3}{94}$	"	2	72 $\frac{1}{8}$	8 0	416	Tubular	"
Royal William, . .	Screw	Wood	—	Plunger, direct	2	65 $\frac{1}{8}$	3 0	500	"	Griffith's
Cormorant, . . .	"	"	—	"	2	45 $\frac{1}{8}$	2 0	200	"	"
Scotia, ...	Paddle	Iron	4050 $\frac{24}{94}$	Side lever	2	100	12 0	1000	"	Radial
Orestes, . . .	Screw	Wood	—	Plunger, direct	2	60 $\frac{1}{2}$	3 0	400	"	Griffith's
Clan Alpine, . .	Paddle	Iron	1507 $\frac{30}{94}$	Inclined	2	64	8 0	400	"	Eccentric
Wolf, ...	"	"	870	"	2	61	6 0	275	"	"
Rolfe Krake, . .	Screw	"	1091 $\frac{13}{94}$	Horizontal, direct	2	48	2 0	235	"	Griffith's
Osman Ghazy, . .	"	"	4221 $\frac{57}{94}$	"	2	92	4 0	900	"	"
Abdul Aziz, . . .	"	"	4221 $\frac{57}{94}$	"	2	92	4 0	900	"	"
Orkman, . . .	"	"	4221 $\frac{57}{94}$	"	2	92	4 0	900	"	"

Total number constructed by this firm, from 1851, inclusive—Screw engines, 87; Paddle engines, 39.

The ratio of fuel consumed in pounds per hour, to the actual horse power per hour expended may be taken as follows: Engines of ordinary construction, power, 1·0; fuel, 5 to 6. For expansive working engines, with superheating and surface condensation, thus: Power, 1·0; fuel, 2·50.

I am deeply indebted to several eminent firms for their courtesy and the practical information received and personally given. Messrs. John Penn & Son, of Greenwich, have kindly given me a tabular statement of much value to the profession and Society. I am advised by this firm that a more extensive list of their trunk engines may be found in the *Artizan* journal for March, 1859, and November, 1861. The list now presented commences from the latter date; also, that with their class of engines their consumption of fuel is about 4 lbs. per actual horse power per hour for those of ordinary construction, and about 2·5 lbs. per actual horse power per hour for expansive engines, with superheated steam and surface condensation. This firm has displayed a warm interest in the present paper, by kindly lending the photographs and splendid working models, which I have the pleasure of laying before you.

Messrs. Maudslay, Sons & Field have kindly lent photographs of their late improvements in marine engines. From personal interviews, I am enabled to present the Society with valuable information, particularly as follows: The amount of fuel consumed, per horse power actual, for ordinary engines by this firm is 5 lbs., in some cases less, and in others more. For three cylinder expansive engines, with surface condensation and superheating, the consumption is reduced to 2·25 or 2·5 lbs. per horse power actual. These engines cut off at one-seventh of the stroke producing an almost correct indicator diagram. In one example shown me, the nominal horse power was 150; with a pressure of steam 25 per square inch, the indicator diagram produced a result of 875 actual horse power, being in the ratio of 1 to 5·833, which may be said to be an exceptional result for screw engines. This firm has constructed, since 1851 to the present time, the following number of engines and boilers: Of screw engines, 183; of paddle wheels, 30. The highest nominal power of one pair of engines yet constructed by this firm is 1350, and the lowest, 10.

The Messrs. Rennie have kindly lent me models and photographs of the different classes of engines they are in the habit of constructing. I am informed by this firm that the consumption of fuel for ordinary engines is: Actual horse power 1, fuel 5. In the case of surface heating, surface condensation, and expansion—Actual horse power, 1, fuel consumed, 2·5; showing a reduction of 50 per cent. on that of the ordinary kind, which is about equal to the other firms.

Valuable statistics have been supplied to me by Messrs. R. Napier & Son, of Glasgow, giving particulars of the ships, engines, &c., constructed by them from 1851, to the present time. From these I have made a selection for publication. This firm has also kindly presented me with splendid photographs of their engines, &c., which are hung for inspection.

With reference to twin screw propulsion, I am deeply indebted to the firm of Messrs. Dudgeon, of Blackwall. They have kindly furnished for this occasion practical statistics of the proportions of vessels and engines constructed by them since the year 1851 to the present time.

In conclusion I must apologize for the length of my present paper; but I beg to observe, that had I extended my remarks to twice or thrice the present length, I should even then have failed of doing justice to this subject which is undoubtedly one of national importance. To the credit of those concerned it can be truthfully said, that, in comparison with other nations, the productions of our marine engineers maintain that high standard for excellency of design and workmanship which has ever characterised the natives of Old England.

(To be continued.)

Suggestions on Drainage Works and Water Supply.

By Robert Rawlinson, C.E.

From the London Civil Engineer and Architect's Journal, August, 1865.

A valuable collection of instructions and suggestions relative to sewers, drains, and water-works has recently been issued by Mr. Robert Rawlinson, one of the Government engineers. Local surveyors, contractors, and others engaged on works of this nature intended to undergo Government inspection, will find them very useful for reference. The rules and suggestions are as follows:

Before a scheme of sewerage is devised, the district should be fully examined, so as to obtain a correct idea of the drainage area, or the several drainage areas; inquiry should then be made to ascertain how surface water has passed off up to the time of such examination, and with what effects. Main sewers and drains should be adapted to the town area, length of streets, number of houses, surface area of house yards and roofs, number of street gulleys, and volume of water supply.

Sewers and drains, in wet subsoil, should be made to act as land drains.

The following rules are general; each surveyor must, however, use his own judgment, and make the best arrangements possible under the circumstances with each special area, and with the materials at command:

1. Natural streams should not be arched over to form main sewers.
2. Valley lines and natural streams may be improved, so as to remove more readily surface water and extreme falls of rain.
3. Main sewers need not be of capacity to contain flood water of the area drained; such flood water may be passed over the surface in most cases without causing injury.
4. Main sewers should be laid out in straight lines and true gradients, from point to point, with manholes, flushing, and ventilating arrangements at each principal change of line and gradient. All manholes should be brought up to the surface of the road or street to allow of inspection, and should be finished with a cover easily removable.

5. Duplicate systems of sewers are not required. Drains to natural streams in valley lines for storm waters may be retained, and may be improved or, if necessary, enlarged.

6. Earthenware pipes make good sewers and drains up to their capacity. Pipes must be truly laid and securely jointed. In ordinary ground they may be jointed with clay. In sandy ground special means must be used to prevent sand washing in at the joints.

7. Brick sewers ought to be formed with bricks moulded to the radii.

8. Brick sewers should in all cases be set in hydraulic mortar or in cement. In no case should any sewer be formed with bricks set dry to be subsequently grouted.

9. Main sewers may have flood water overflows wherever practicable, to prevent such sewers being choked during thunderstorms or heavy rains.

10. Sewers should not join at right angles. Tributary sewers should deliver sewage in the direction of the main flow.

11. Sewers and drains at junctions and curves should have extra fall to compensate for friction.

12. Sewers of unequal sectional diameters should not join with level inverts, but the lesser or tributary sewer should have a fall into the main at least equal to the difference in the sectional diameter.

13. Earthenware pipes of equal diameters should not be laid as branches or tributaries—that is, 9 ins. leading into 9 ins., or 6 ins. into 6 ins., but a lesser pipe should be joined on to the greater, as 6 ins. to 9 ins., 9 ins. to 12 ins., 12 ins. to 15 ins.

14. House drains should not pass direct from sewers to the inside of houses, but all drains should end at an outside wall. House drains, sink pipes, and soil pipes should have means of external ventilation. The largest block of buildings may have every sewer outside of the main walls. No foul water drains nor cesspit should be formed beneath any house basement. All fluid refuse should pass at once from the drains to the sewers and from the sewers to the outlet.

15. Sinks and water-closets should be against external walls, so that the refuse water or soil may be discharged into a drain outside the main wall. Down spouts may be used for ventilation, care being taken that the head of such spout is not near a window. Water-closets, if fixed within houses, and having no means of direct daylight and external air ventilation, are liable to become nuisances and may be injurious to health.

16. Inlets to all pipe drains should be properly protected.

17. Side junctions should be provided in all sewers and drains. The position should be sketched, and indicated by figures in a book or on a plan. Side junctions not used at once, should be carefully closed for subsequent use.

18. A record should be kept by the surveyor of the character of the subsoil opened out in each street sewered or drained.

19. Sewers and drains should be set out true in line and in gradient. All the materials used should be sound, and the workmanship should be carefully attended to.

20. Sight rails should be put up in each street before the ground is opened out, showing the centre of each water sewer and depth to the invert.

21. Sewers having steep gradients should have full means for ventilation at the highest points.

22. Tall chimneys may be used with advantage for sewer and drain ventilation, if the owners will allow a connexion to be made.

23. Sewers outlet works should be simple in form, cheap in construction, and so arranged as to remove all solids, sediment, and flocculent matter from the sewage.

In executing town sewers and drains, danger may be anticipated from several conditions, as under:

Where a street or place is narrow, with buildings on both sides, and where the trench is deep; where the substrata is clay or marl, made ground, loose earth, bog and silt, quicksand, or any combination of such strata.

Quicksand is the most difficult to deal with, and, as a rule, such ground should only be opened in short lengths; this ground may require to be close timbered, and in such cases stable litter and ashes will be found useful to pack behind and betwixt the polling boards.

Sound looking clay or marl may require careful timbering to prevent heavy breakings from the sides of the trench. When such ground "sets" heavily, the sewer, if of bricks, may be seriously injured; if of earthenware pipes, it may be ruined by cracking, or by crushing and distorting the line of sewer or drain pipes.

As a rule, all sewer and drain trenches in towns should be carefully timbered, and such timbering must either be left in, or be most carefully removed as the trench is filled.

The houses and buildings in narrow streets may require to be propped and stayed; if so, such props and stays ought not to be removed until the sewer or drain has been completed, and the ground become perfectly consolidated.

In many cases it will be cheaper, because safer, to leave timbering in deep trenches, and where there is special danger the trench may be filled with concrete.

A foreman in charge of sewer works is expected to be on the watch to see that the men execute the work safely. The local surveyor must see that timber sufficient in quality and quantity is supplied to secure all open trenches, and the buildings on either side.

Where ground is known to be specially dangerous, all available precautions must be taken to prevent accidents.

It is of the utmost importance to impress upon local surveyors the necessity of care in setting out main sewerage works and house drains with accuracy, in choosing sound materials, and in properly superintending the works during their progress. House drains should be so arranged as to be capable of removing all water, soil, and fluid refuse from yards, roofs, and interiors of houses to the sewers, without any risk of gaseous contamination to such houses.

Street sewers should be capable of conveying all sewage to some

common outlet, without retaining sediment in them. All sewers and drains should have arrangements for full ventilation at such points and in such manner as not to cause any nuisance. Charcoal (as proposed by Dr. John Stenhouse) may be used to filter and disinfect sewage gases at all manholes and other ventilators.

If the fluid sewage can be applied to land for agricultural uses, means should be provided for effecting this purpose.

Water-closets should have a daylight window (not a "borrowed light") and fixed means for ventilation, which can neither be seen nor be tampered with. Permanent openings, equal to a slit of 12 inches in length and 1 inch wide, should be provided. The cover or lid of the seat should be made to close and leave the valve handle free, so that the contents of the closet may be discharged with the lid closed down. At all times when a water-closet is not in use the lid or cover should be closed.

Water Supply.

Where a district is to be supplied with water, all other things being equal, the softest and purest water should be adopted.

A water supply may be gravitating, or the water may be pumped by steam power. The relative economy of one or the other form of works will depend on details of cost and quality of water. As a rule, gravitating works require the largest capital. The annual working expenses of a pumping scheme will frequently be greatest.

1. Plans and sections of the proposed gathering ground of any storage reservoir, geologically colored, should be produced on a scale not less than six inches to the mile.

2. The area of the gathering grounds proposed to be affected should be given in statute acres.

3. Plan of storage reservoir and works immediately connected therefrom must be at a scale not less than four chains to the inch.

4. The fall of rain in the district for not less than seven years, ought to be produced.

5. Trial shafts shall be sunk in the centre line of the site of the proposed embankment, at a distance not greater than 100 feet apart. The results and details relative to the stratification obtained from such trial shafts shall be produced.

6. Plans of the proposed outlet and other works, in detail, at a scale of not less than 20 feet to 1 inch must be prepared. Such details should exhibit the embankment in plan, and also cross sections at the deepest part of the proposed embankment. The following detail drawings shall also show:

a. Top bank width of embankment.
b. Inner and outer slope of bank.
c. Puddle wall and puddle trench.
d. Relative level of by-wash below top bank level.
e. Outlet works.
f. By-wash and by-wash conduit.

7. The capacity of the reservoir, to the level of the by-wash, to be stated in cube feet.

8. No puddle wall shall be less in width at the top water line, in any part of the embankment, than 8 feet, and shall increase for each foot of vertical height not less than 1 inch in width on each side of such puddle wall, down to the ground line at the deepest part of the embankment. Similar proportions shall be preserved throughout the entire line of the puddle wall. The puddle trench shall be filled entirely with puddle.

9. The inner slope to the embankment shall not be less than three horizontal to one vertical. The outer slope shall not be less than two and a half horizontal to one vertical. Embankments should be formed in layers of earth not more than 12 inches deep, spread evenly over the entire area of such embankment; neither railways nor tramways should be used on a water-works embankment, but dobbin carts or wheelbarrows. An embankment should be formed evenly and regularly, the puddle wall and the rest of the bank being brought up simultaneously.

10. The finished top bank width of any reservoir shall not be less than the following dimensions, namely:

An embankment 25 feet deep, not less than 6 feet wide.
" 50 " " 12 "
" 75 " " 18 "

Intermediate, or lesser, or greater depths of embankment may have proportionately arranged widths.

11. The finished top bank level of any reservoir shall not be at less than the following elevations above the edge of the by-wash or top water line of a full reservoir, namely:

An embankment 25 feet deep, not less than 4 feet.
" 50 " " 5 "
" 75 " " 6 "

Intermediate, or lesser, or greater depths of embankment may have proportionately arranged relative top bank and by-wash levels.

12. Each impounding reservoir shall have full and free by-wash space not less than three feet in length for every hundred acres of gathering ground; such by-wash, where practicable, to be formed in the solid ground.

13. Cast iron pipes, culverts of timber, or other material liable to decay, shall not be used for outlet discharge, or for overflow works, if required to be buried under or within any reservoir embankment in such manner, and in such dimensions, as to preclude repairs, and endanger the structure by decay. Valves and sluices should be placed within the line of puddle wall.

14. A reservoir embankment shall, at all times, be preserved at its full height, and the relative level of the top bank and by-wash be preserved.

15. All reservoir works and apparatus, such as goits, culverts, tunnels, conduits, by-washes, cloughs, sluices, valves and working machinery connected with such cloughs, sluices, and valves, shall be maintained sound and in good working order.

Reservoirs for service distribution should be covered.

Water should not be exposed in open reservoirs and tanks after filtration.

Cast iron pipes, properly varnished, should be used for street mains. It is not advisable to use mains less in internal diameter than three inches.

Lead should not be used either in service pipes or house cisterns. Wrought iron tubes with screw joints may be used for house service. All house taps should have screw joints, and be of the description known as screw down, so as to admit of easy repairs.

In jointing and fixing wrought iron service pipes care should be taken to insert double screw joints at convenient points, to allow the removal of a length of pipe for alterations and repairs.

Up-bends should be avoided, or a tap should be inserted to allow any accumulation of air to escape.

Wrought iron service pipes are cheaper, stronger, and more easily fitted than service pipes of lead. Certain sorts of made ground in towns act rapidly and injuriously on both lead and iron pipes—furnace ashes, waste gas, and chemical refuse, old building refuse containing lime and other such material. Pipes should not be laid in such material without a lining of sand or puddle, or other special protection.

Earthenware pipes may be used for water conduits, provided the joints are not placed under pressure.

A public supply of water should not be less in volume than 20 gallons daily per head of the population. This, in towns below 20,000 population, will include water for public purposes and for trade requirements. High pressure and constant service should be secured wherever practicable.

Water at and below six degrees of hardness is "soft" water, above this range water is "hard."

Hardness in water implies one grain of bicarbonate or sulphate of lime in each gallon of water.

Each degree of hardness destroys 2½ ounces of soap in each 100 gallons of water used for washing. Soft water is, therefore, commercially, of more value than hard water, in proportion to the worth of 5 ozs. of soap to each 100 gallons for each degree of hardness. But soft water is also more wholesome, and effects saving in other operations—tea making, and in generating steam power.

The Field Boiler, its Principle, Construction, and Action.

By Francis Wise, C.E., M. Inst. E.S., &c.

From the London Civil Engineer and Architect's Journal, June, 1865.

(With an Engraving.)

The object of what is commonly known as a steam boiler, is to impart the heat evolved by the combustion of any suitable fuel, to water contained in a close vessel, in such a manner as that evaporation may ensue, and that the vapor given off may be employed as a source of power or for other purposes; and further, it must be admitted that,

other things being equal, the less time and space occupied in evaporating any given quantity of water the better. It is evident, however, that if increased rapidity of evaporation is to be achieved at the cost of economy of fuel, of space, or of safety, the advantages of quick evaporation will be either neutralized or diminished.

In the Cornish and other boilers in that class, the heat generated in the furnace is not absorbed with sufficient rapidity by the water to render quick combustion economical, inasmuch as with it a considerable proportion of the heat evolved by the burning fuel, instead of being taken up by the water, is either absorbed by the brickwork of the flues or passes away uselessly by the chimney. The reason, therefore, of the superior economy of slow combustion in Cornish boilers is, that they require a considerable time to take a fair per centage of the heat generated, and that unless sufficient time is allowed them for doing so, a certain proportion of the heat is wasted, which indeed simply amounts to saying that the Cornish boiler is imperfect in principle, (insomuch as, beyond a comparatively low limit, it is incapable of utilizing a proper proportion of the heat capable of being generated in its furnace,) and does not in any way go to show that, with a boiler capable of rapid absorption, slow combustion is either advantageous or desirable. At all events, it is obvious that, if by using an improved construction of boiler we can evaporate the same amount of water as is evaporated by the best Cornish boilers, with greater safety, and at least equal economy of fuel, in a space of about one-sixth what is necessary under the Cornish system, there is a clear gain of much importance; and if to this can be added greatly increased accessibility and non-liability to wear and tear in the body of the boiler, we shall have made a decided and highly important step in advance.

How, then, is this to be done? It is clear that anything approaching to the Cornish system, with its long and partly useless flues and large body of sluggishly circulating water, is out of the question. Turning, then, to multitubular boilers, in which the heated products of combustion are conveyed from the furnace to the chimney, by a number of small tubes passing through the water space and intended to impart heat to the water, and what do we find to be the result? Why, that flame entering the tubes is almost immediately extinguished, through want of a proper supply of oxygen, and that the heated products of combustion, to a great extent, pass through the tubes without their heat having been absorbed by the water surrounding them, and that the more rapid the combustion, the greater (owing to the imperfect circulation) is the proportionate loss of heat. This, then, in its present form, is evidently not the system whereby the end desired is to be achieved.

If these premises be correct, two things are clear, viz: first, that we cannot use the Cornish system with its large body of inert water; and secondly, that the plan of passing the heated products of combustion in threadlike streams through the water space, as in the ordinary multitubular boiler, is also practically incorrect.

Let us now suppose that, instead of passing the products of combus-

tion in small streams through the water, we cause the water itself to pass in like streams (and with a rapidity of flow self-proportioned to the heat whereby it is surrounded) into and through the hottest part of the furnace. The result will then be that, with slow combustion, the circulation will be slow, so that the quantity of water presented to the action of the fire in any given time will be exactly suited to its heat imparting power; and that if the rapidity and intensity of the combustion be increased, the rapidity with which the water will pass through the furnace will be proportionately increased, and this will be so even although the fire be urged to give out the greatest possible amount of heat. Hence it is evident, as the velocity of the circulation is in all cases regulated by the heat giving power for the time being of the furnace, it matters not whether the combustion be slow or quick, excepting that, in the latter case, we shall be enabled, by the greater velocity with which the streams of water pass through the furnace, to evaporate a proportionately greater quantity through the same space. Now, this is precisely the principle of the boiler under notice, the practical results of which entirely corroborate the foregoing remarks, and satisfactorily prove that the principle of submitting the water, in small and rapidly circulating streams, to the most intense heat of the furnace, is the true one, and superior to any other yet introduced; as also that, in this way, almost the whole of the heat generated in the furnace (with the exception of what is necessarily employed for the purpose of maintaining a sufficient draught) may be utilized in the production of steam, and that economy of space and weight may thus be made to go hand-in-hand with that of fuel.

A consideration of the construction of the Field boiler will at once show how these effects are produced, while the boiler itself is at the same time rendered safer than any other kind of boiler in existence. It should, however, be first mentioned, that the principle of construction adopted in the Field boiler is not only applicable to boilers for stationary purposes, but also with equal advantage to those of the marine and portable class; and, with reference to the latter class, has proved itself capable of going through the most severe work uninjured, under which other boilers have required constant repair, and have never, at the best, been free from leakage. The construction of the Field boiler is this:

It consists of two principal parts, namely, the water and steam space, or body of the boiler, and the furnace or chamber wherein the fuel is burnt. For stationary purposes the boiler is made cylindrical in form with an annular space *a*, surrounding the furnace *b*, as shown in Fig. 1, of the accompanying Plate I, but the form may be readily varied and adapted as required to suit any peculiarities of circumstance or position, whether for land or marine purposes. In the case of the cylindrical vertical boiler referred to, a number of tubes *c*, placed annularly around a fire-tube *d*, passing upward through the boiler, hang down or are pendant from the under side of the water and steam space *e*, into the furnace *b*.

These tubes are open at their upper ends into the water space, and,

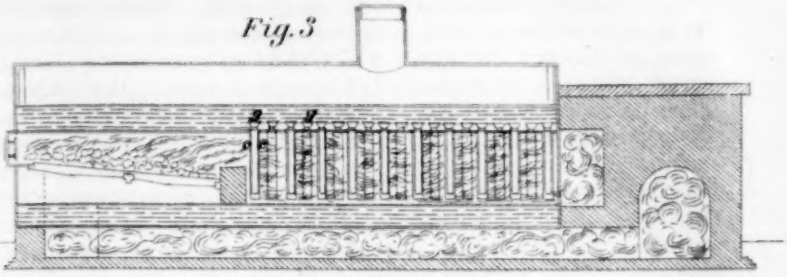
being closed at the lower ends, are consequently (when the boiler is in readiness for starting) entirely filled with water, the top level of which is some inches above their upper ends. Within each of these tubes is freely suspended, by means of feathers *x*, a smaller tube *f*, open at both ends, the upper end of which rises above the level of the upper end of the outer tube *c*, but is short of reaching the bottom of it. The tops of these inner tubes are provided with trumpet or funnel-shaped mouths or deflectors *g*, which, as will be seen, perform an important part in the action of the boiler. A baffle plate or cylinder *h*, suspended beneath the opening into the flue-tube *d*, which passes upwards through the boiler, prevents any portion of the heat of the furnace from passing away without having first enveloped and become almost entirely absorbed by the pendant tubes and the water circulating within them.

Boilers upon this principle are peculiarly adapted for marine purposes, insomuch as not only is the body of water which they contain, and which is liable to surge from side to side by the roll of a vessel, considerably less than in boilers of the ordinary construction, but it has been found that they may be worked with water completely saturated with salt. Indeed, experiments which have been made show that even with a supersaturated solution; that is to say, a solution which after saturation has been further evaporated until a considerable portion of salt is held only in mechanical suspension, the tubes work well, and will, on the relighting of the fire, absolutely eject the salt which has settled in them during a period of rest, even although its depth may be sufficient to cover the bottoms of the inner tubes. A boiler of this kind is shown in Fig. 2, in which *b* is the furnace, the flame and heated gases from which, after passing the bridge *q*, continue onward among a series of pendant double tubes, and returning along a flue—also containing pendant double tubes—towards the front of the boiler, pass away by the uptake *d*. The double tubes thus arranged, and not too closely packed, permit the flame of the furnace to play among them for a considerable distance without extinction; and by the position of the surface they present to the flame and heated gases are most effective in their more economical results. This was curiously shown in the case of a Cornish boiler, to which a few of the double tubes were applied in the main flue, immediately behind the bridge, in the manner shown at Fig. 3. In this case the amount of heating surface added to the boiler was 10 per cent., but the saving of fuel, instead of being in the same proportion, was more than 20 per cent.; and it was found in this case, when there was only a thickness of about $\frac{3}{8}$-inch of iron in which to fix the tubes—as had previously been found with boilers having tube plates of greater thickness specially intended to receive and support the double tubes—that such was their perfect freedom of expansion and contraction, that there was not a drop of leakage.

It will thus be seen that this system, in addition to its other advantages, does away with that serious and inevitable defect of tubes fixed at both ends, namely, leakage, the destructive effects of which are well known to every person who has paid any attention to the working of boilers; and further, the same feature which does away with

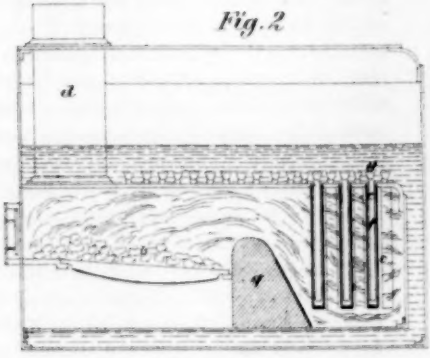
THE "FIELD" STEAM BOILER.

Fig. 3



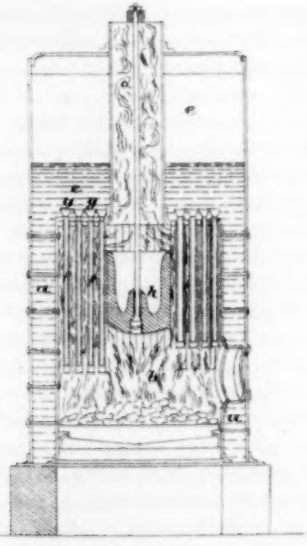
Cornish Boiler with Field's Tubes

Fig. 2



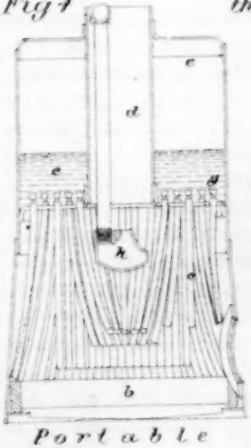
Marine

Fig. 1



Stationary

Fig 4



Portable

Enlarged View of the Tubes e & f

the very serious evil referred to, has an important effect in lessening the first cost of the boiler, insomuch as it enables the tubes to be securely and perfectly fixed, simply by a very slight expansion of their upper ends, without the use of any ferules or other objectionable arrangement. To fix the tubes all that is necessary is to make the holes in the tube-plate slightly conical, their diameters at the lower surface of the plate being equal to those of the tubes, and their upper diameters somewhat larger, and then, after having slightly expanded the upper end of the tube, to place it in its intended position, and by means of one or two blows with a hammer upon a steel conical mandrel inserted in its upper end, to further expand the tube, so that it may fill and jam itself in the hole in the plate.

The facility with which a tube may thus be fixed is a matter of great importance in case of injury occurring to a tube during the working of the boiler, as at the worst it involves only a trifling delay before the damaged tube can be replaced and the boiler again put in perfect working order, without its being necessary even to call in the assistance of a skilled workman, a class of individuals generally found to be unobtainable at the very time when most urgently wanted.

The boilers for stationary purposes as already described, though calculated for steady and continuous working, and economical in consumption of fuel, are not, at the same time, so heavy or cumbrous as to preclude their being used with advantage for various description of portable engines, as, in point of fact, they are lighter than those ordinarily used for such purposes, and, where extreme lightness is not of paramount importance, are certainly the most desirable form of boiler to employ. There are cases, however, and that of steam fire engines is one of them, in which extreme lightness and portability in the boiler, combined, with a power of raising steam with great rapidity, are of more importance than economy in fuel. In such cases it is obvious that the weight of the water casing, and of the water contained in it, would constitute a comparatively serious objection to the employment of the water cased boiler, which would be also further objectionable on account of the extra time required to heat the additional quantity of water contained in the casing. For purposes, therefore, of the kind referred to, the boiler used is of the type represented at Fig. 4, in which the water casing is entirely dispensed with, and the tubes used —which are of smaller diameter than those used in the other types—are so arranged as that the lower ends of the outer circles constitute an almost continuous casing around the fire-grate.

In working these boilers, a steam jet is used as soon as steam appears, for the purpose of urging the draught, and is continued in action until the engine is started, when the jet is shut off and the draught is maintained by the exhaust steam which passes by the pipe into and through the hollow baffle, whence it issues into the chimney. These boilers were designed for and are used with the greatest success in the steam fire engines manufactured by Messrs. Merryweather & Sons, whose small class engines, weighing in all about 30 cwt., raise steam from water, which, at starting, may be little above freezing, to a pres-

sure of 100 lbs. on the square inch in 9¼ minutes, and maintain the pressure undiminished while doing absolute work, in raising water to the extent of over twenty horses power. The engine Sutherland, which weighs complete only 2 tons 18 cwt., is fitted with a boiler of the same class, and has shown wonderful rapidity in raising and generating steam. Thus, at the Crystal Palace, this engine raised steam from cold water to a pressure of 100 lbs. on the square inch in ten minutes, and subsequently threw a jet from a 1⅛-inch nozzle vertically to a height of 200 feet, and maintained it steadily up to a height of more than 180 feet, for over five and twenty minutes, showing itself capable of continuing to do the same for any length of time desired. The boilers of the first named class of engine are 2 feet 3 inches in diameter, and, inclusive of furnace, are only 4 feet 6 inches high, while that of the latter is 3 feet 6 inches in diameter, and 4 feet 6 inches high.

In order to obtain the required large amount of steam from boilers of such disproportionately small dimensions as these, it is obviously necessary that the heat of the furnace be of the most intense character, and it is equally obvious that, in order to maintain it to that intensity, a very large supply of air must be drawn through the burning fuel, and as this can only be done by means of a proportionately fierce draught, it naturally follows that a considerable per centage of heat is wasted, not, indeed, by reason of any deficiency of absorbing power in the boiler, but on account of the disproportionate strength of draught required to draw the necessary amount of air through the furnace, and which, consequently, not only compels the rapid rush of too large a proportion of the heated gases up the chimney, but also, at the same time, carries with them a by no means insignificant amount of the burning fuel itself. Yet, notwithstanding the disadvantages under which they thus necessarily labor, and which are in their nature so inimical to economy in fuel, the workings of these boilers show results quite equal to those of the majority of ordinary stationary boilers, and therefore form another convincing proof, if any were required, of the correctness of the principle upon which their construction is based.

A consideration of what takes place in the working of the Field boiler will at once clearly show why it should in all cases contrast favorably with other boilers employed under similar circumstances. Thus, taking for example the size of stationary boiler known as 80-horse, but which will in reality work with ease up to 120 horse power, the outer diameter of this boiler is 6 feet 6 inches, and its height 8 feet 8 inches. It contains 490 square feet of tube surface, the outer tubes being 2 inches in internal and 2¼ inches in external diameter, and the inner 1 inch in diameter. Now, upon lighting the fire, the water in these tubes immediately commences to circulate every increment of heat, however trifling, added to the water contained in the annular spaces between the inner and outer tubes, lessening its specific gravity and causing it to ascend, and cold water to consequently descend the inner tubes to supply its place. This action goes on increasing gradually in rapidity until ebullition commences, at which time the velocity of flow is increased enormously, owing to the great difference between the specific gravity of

mixed water and steam ascending in the annular spaces, and that of the solid water descending the inner tubes.

Taking the velocity of flow down the inner tubes at 10 feet per second, and the number of tubes at 289, we shall have a quantity of water equal to about 96 gallons passing down into the furnace, and being submitted to its most intense action in every second of time. Moreover, owing to the principle of action of the tubes, the water so submitted necessarily belongs to the less heated portion of the contents of the boiler, and consequently possesses the greatest capacity for heat. Now, when we consider that an amount of water equal to the entire average contents of the boiler is thus passed into the furnace, with the intervention of only one-eighth of an inch of metal between itself and the fire, in every six seconds of time, some idea may be formed of the immense rapidity with which the heat of the furnace may be passed into the water, which may be further strengthened by reflection on the well known fact, that if it be attempted to harden a tolerably large piece of steel by plungiug it when hot vertically into cold water and hold it motionless in that position, the attempt will prove a failure, inasmuch as the water will fail to carry off the heat from the steel with sufficient rapidity to effect the hardening, but if, instead of holding the steel motionless as described, we move it more or less rapidly from side to side through the water, the hardening will be at once effected. Now, this is precisely the difference between the ordinary kinds of boiler and the one which forms the subject of this paper. In each case we have, on the one hand, a mass of water subjected to heat, and unable to change its position with sufficient rapidity to absorb the heat presented to it; and on the other, a constantly changing surface of fluid, carrying off the heat from the metal with great rapidity, and in case effecting the object desired.

Here, then, is one very obvious reason for the economical results achieved by these boilers, even under circumstances which might seem to put economy out of the question, the fact being simply that, in ordinary boilers, the circulation, left to shift for itself, has great difficulty in becoming of a decided character in any direction, so that the water, instead of taking off, or, as it may be expressed, rushing off with the heat from the metal as required, hangs about it, and with comparative slowness conducts it away. The consequence is that much of the heat passes into and away by the flues instead of into the water, and thus it is, as was before remarked, that slow combustion with ordinary boilers necessarily shows to better advantage than quick. It is important in discussing the merits of any boiler to advert to the difficulties, if any, likely to arise from the deposit on its surface of these troublesome matters, the sulphates and carbonates of lime, or other such compounds of them as are usually thrown down in the form of a hard scaly incrustation. It is well known that such deposits are encouraged by sluggish circulation, and that where the circulation is most feeble, as well as in the neighborhood of the feed pipe where the water first enters the boiler, the deposit is usually thicker than at any other places. Bearing this in view, we are naturally led to expect that the effect of very rapid

and constant circulation will be to prevent deposit in the channels wherein such circulation takes place, and are therefore scarcely surprised to find that the tubes of boilers of steam fire engines constructed upon the Field principle, and worked almost daily for two years, have remained entirely free from deposit.

It may be that some small part of this remarkable result is due to the continual changes of water, with which, from the nature of their duties, these boilers are worked; but assuredly, if that be so, the part borne by these changes in preventing incrustation is very small indeed. But allowing that continual change of water had some appreciable influence in the matter, stationary boilers on the Field system now at work show that with the most ordinary precautions there is practically no incrustation. The writer was present lately at the opening of one of these boilers for the usual quarterly examination, and is enabled to state that there was no hard or scaly deposit whatever. At the bottom of the water space there was a light colored mud, which, when dried, proved to be an impalpable powder, consisting, doubtless, of the matters which, in ordinary cases, are deposited in boilers in the form of hard incrustation, but which, in this case, had been kept in mechanical suspension until finally thrown down into the water space as described. The precautions which had been taken in this instance, and which were so thoroughly efficient, were of the most simple character, and consisted, first, in the employment of an inexpensive water heater, whereby some of the calcareous matters contained in the water were thrown down previous to its entrance into the boiler; and secondly, in the use in the water of a trifling quantity of composition, known as Buck's, and consisting, apparently, chiefly of soda, which seemingly had the effect of completing whatever was left undone by the heater.

These facts dispose of the only point suggested by practical men as likely to prove a source of difficulty with the Field boiler, and leave its important advantages of economy in fuel and of space, ease in firing, accessibility for examination and repair, and perfect safety, without any corresponding drawback.

Exploration of Palestine.

From the London Athenæum, July, 1865.

Last week we announced the return of Captain Wilson and his party from Palestine, with a large collection of drawings and observations.

On Thursday, he met the newly named Committee of the Palestine Exploration Fund, in the Jerusalem Chamber, Westminster, when he reported on the prospects of excavation in Syria, and particularly in Palestine. After much consideration of the means now placed at the disposal of the Committee—a sum of about 2000*l.*—and the great work to be accomplished, it was resolved, with the permission of the War Office, and the sanction of Earl Russell, to send Captain Wilson and his exploring party back to Jerusalem, instructed to make a general survey of the country with a view to the future operations of the Society

when it shall have obtained a larger measure of public support. He is to consider Jerusulem and Nabalus as his principal fields; he is to take levels and observations, to dig in the foundations of walls, to trace conduits and sewers, to examine tells and mounds, and otherwise carry on the preliminary business of exploration. The labors of the Committee are, therefore, commencing well, and if the members will keep clear of all controverted theories and individual crotchets, there is every hope of success. The danger lies there. The Committee is the result of many compromises—at present, it represents nearly all the schools of archæology; and its officers must take care to avoid the appearance of partizanship. Let all opinions have a hearing, and the public will have confidence in the wisdom of such measures as may be finally adopted. Captain Wilson will return to Palestine in October.

The Leveling of the Mediterranean.

From the London Athenæum, July, 1865.

The leveling from the Mediterranean to the Dead Sea has been performed with the greatest possible accuracy, and by two independent observers, using different instruments, and the result may be relied upon as being absolutely true to within three or four inches. The depression of the Dead Sea on the 12th of March, 1865, was found to be 1292 feet, but from the line of driftwood observed along the border of the Dead Sea, it was found that the level of the water at some period of the year, probably during the winter freshets, stands 2 feet 6 inches higher, which would make the least depression 1289·5 feet. Captain Wilson also learned from inquiry among the Bedouins, and from European residents in Palestine, that during the early summer the level of the Dead Sea is lower by at least 6 feet; this would make the greatest depression to be as near as possible 1298 feet. Most of the previous observations for determining the relative level of the two seas gave most discordant results. The Dead Sea was found by one to be 710 feet above the level of the Mediterranean, by another to be on the same level, by another to be 710 feet lower, and by another to be 1446 feet lower; but the most recent before that now given, by the Duc de Luynes and Lieutenant Vignes, of the French Navy, agrees with our result in a very remarkable manner, considering that the result was obtained by barometric observation, the depression given by them being 1286 on the 7th of June, 1864, which at most differs only 12 feet from the truth, if we suppose that the Dead Sea was then at its lowest. In my instructions to Captain Wilson, I gave directions for bench marks to be cut upon the rocks and buildings along the line leveled from sea to sea, and for a traverse survey to be made of the whole distance, upon which the places where the bench marks can be found can be represented. This traverse will be given with the plans in the atlas, as well as the diagram of the triangulation around Jerusalem, and these cannot fail to be of great value for any more extended surveys which may be hereafter undertaken in Palestine.

MECHANICS, PHYSICS, AND CHEMISTRY.

For the Journal of the Franklin Institute.

Expansion and Propulsion.

All persons are familiar with the transcendent achievements of steam power, and almost all consider them prelusive to others still greater, but while every one sees what it does, comparatively few perceive how it is done. Ideas of it that reach no further than external features and movements of an engine are indefinite and more or less cloudy and chaotic. Even with engineers themselves, there are points on the evolution, treatment, action, and applications of the fluid far from being lucid and sharply defined. Opinions greatly vary. Two examples may here be quoted,—one of marked interest to the engineering community, the other of greater importance to the national and commercial marine: 1. The economy of expansion by cut-offs. 2. The virtue of *form* in propelling blades. The competing engines of the *Algonquin* and *Winooski* will go far to settle the first, but not the second, without removing the undershot water wheels, suspended as paddles, over the sides of both vessels.

Of the economy of stopping the flow of steam into a cylinder before the piston reaches its ends, there is and has been no diversity of opinions; the fact is palpable, and such has been the uniform practice since the beginning. The points in dispute are the extent to which the principle is urged, and the amounts of gain claimed. Prevailing opinions, right or wrong, have always governed, and much that is due only to reflection and demonstration is still yielded to popular dogmas, to interest and feeling. Inventors oftener build without data than with them, and, what is worse, their propositions are too commonly made bases of speculation. All this is natural, at any rate unavoidable; nor is it, on the whole, to be regretted that truth in mechanical, as in other departments of research, has to be reached through conflicts with interests and error. Without efforts to attain it we could neither be prepared to receive it, nor capable of appreciating it. That which costs little or nothing is held of small account.

While admirers of "independent" cut-offs dwell complacently on that part of the operation to which "the great saving" is attributed, others glance at what they hold as a full counterbalance. Thus, when a charge cut off at one-third drives the piston through the remaining two-thirds, a clean profit is claimed. To this other observers say nay; that against it should be placed the expenditure of two-thirds more power—steam—on the first part of the stroke than was necessary, and hence that what is gained at one point is lost in another; at all events, that the difference is rather slight than serious. But may not the surplus force on the first part be recovered and applied to the latter? No, not a particle. Misspent force can no more be recalled than misspent time. It vanishes with its action and no longer exists. Yet the steam is still in the cylinder: Granted, but it no longer possesses the power gone out of it. The power is in expansion, and while the piston was station-

ary it was intact, but diminished as that gave way before it. At a first glance the loss may not be apparent, but the difficulty will vanish when it is remembered that communication with the boiler is not closed till the piston has passed through the cylinder to the point fixed on for the cut-off to act. Till then, the loss is made good from the boiler, and consequently does not appear in the cylinder. Could unproductive or misapplied force, of any kind, be recovered and turned to profit, the economy of creation would be very different from what it is.

It would moreover be a marvel if additional power could be got out of a definite quantity of steam by increasing its tension—if one-third of a charge at 90 lbs. on the inch were more effective than a full one at 30 lbs. As well expect to spin more thread out of closely than loosely packed cotton. Compression can add nothing to the fibre or fluid. The gain, however, is ascribed to economy in expending the fluid rather than to an increase of its quantity, and engineers on both sides of the Atlantic have indorsed the system. The government experiments will, it is presumed, definitely settle the question. When they are completed and published we shall learn whether the principle of high or extreme expansion is to be preferred to the doctrine of those who hold that the available force of the charge can vary but little, whether compressed into $\frac{1}{10}$, $\frac{1}{4}$, or $\frac{1}{2}$ of its initial volume—that disbursing steam and money is much the same, a gold dollar going no further than a silver one, nor it varying in value, whether laid down in one piece, or in halves, quarters, or dimes. There are probably no expenditures of force unattended with loss or waste, but by no system of saving can the principle be reversed and the outlay of one portion command a return due to a greater.

It is to the second proposition this paper is intended more especially to invite attention—one of high import to the government, since it involves the question of speed, and that in vessels of war is vital, is everything. It has elsewhere been remarked that an increase of a few knots in our cruisers would have virtually ended the late horrible war two or three years ago, saved thousands of lives, and multiplied millions of money—that it may as well be obtained as current rates, and will be, though perhaps not without further struggling against a plain law of physics—plain and perfect to those who look into it, a stumbling block and foolishness to those who do not; that is, those who prefer rectangular planks to the form of blade which science proclaims, and nature everywhere confirms—whose ideas of driving ships over seas and rivers are those of the builders of Roman gallies, and engineers of the Middle Ages. They propelled vessels by two, four, and sometimes six oxen. Two were yoked to and traveled round a vertical shaft, and each shaft carried a pair of paddle wheels identical with those by which they ground corn on the edge of running streams, and in boats anchored on rapid rivers.

If there are other examples of non-advancement over the dark ages as gross as this we know not where to look for them. Our planet is a school for engineers, as for other professions. It is alive with illustrations of mechanical laws, as fixed and immutable as the universe

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itself; and nothing is more certain, that only so far as our devices accord with them can they succeed. Thus it will be, as heretofore, with the propelling blades of a steamer as with the force that propels them. Abortive *must* be all attempts to make her speed what it ought to be as long as the principle of *form* so distinctly and variedly manifested in organisms that move rapidly through air and water is ignored. It is fundamental. No finite intelligences can improve or supersede it. There is marvellously more in it than common observation perceives. It governs other attributes. Endless are the projects on minor points, and all of them fruitless for lack of that which only can give value to any.

Every horizontal section of a blade has a different velocity, and, to make the resistance and effect uniform, its width must *diminish with the dip*. The centre of resistance, instead of being near the extremity, will then be drawn in towards the centre of the blade, and economy of force will result. There is, in fact, a reciprocal influence pervading every part, every feature and movement of a perfect blade; and wherever this harmonious action does not exist, loss of speed and waste of power are and will forever be inevitable, for physical laws are eternal. There are some things which the present state of science and the arts cannot accomplish, but there is no obstruction, mental or physical, to our giving to sea-boats a maximum of speed with a minimum of force—to our rivalling in this respect the ablest engineers of the future!

If not disgraceful, it certainly is not creditable to American and European engineers that the problem has not been solved before now. It would seem impossible for it to be much longer neglected. The present opportunity of again bringing it to the notice of the Navy Department is singularly favorable. Numerous public vessels have been sold, and more are yet to be disposed of. Out of so many, one or two might surely, and without injury to the public interest, be detailed for the purposes of experiment. The British government has experimental steamers, and much more should ours; but passing that, all that is now asked that the *Algonquin* or *Winooski*—the one which proves the fleetest in the approaching trial—be fitted with blades on the principle recommended in the Patent Office Report of 1849. It is therein demonstrated that speed is essentially affected by the *figure*, *thickness*, and *number* of the blades—that their propelling power expands and contracts with the volumes of water they displace. Ocean steamers had them of 2½, 3½, and even 4 inches thick, amounting to from four to five hundred cubic foot of solid timber to be kept whirling through air and water, and losing on the average 7 feet of effective stroke (the aggregate thickness of one wheel's blades) at each revolution: some wheels actually lost 12 feet of stroke at every turn. But there were engineers then who maintained the hypothesis "the thicker and heavier the blades the better, for the heavier the wheels the easier they work!"

The *length* of paddle planks then varied from 12 and 14 to 22 feet! The incessant jar arising from their striking the water was shown to be a ceaseless source of destruction to both engine and vessel, as well

as waste of power. Some boats had wheel houses wider than their decks, so as to make it doubtful to strangers to such craft whether the hulls were accessories to them or they to the hulls. In this respect the number of blades has been greatly reduced. There where then steamers with 36. The *United States*, among others, had one bolted to each side of her radial arms or levers. The number settled down to 28, next to 14, and now there are examples of only 7 being employed as urged in the Report. But the most important suggestion is yet ignored by those who have taken advantage of the rest, and, with scarcely an exception, without the slightest acknowledgment. It will, however, yet be conceded that the naked arms of old steamers wheels would, if sufficiently lengthened, have propelled them more effectually than the usual plank paddles attached, because of their approximating the only principle applicable to the case—that which nature illustrates in the long, narrow and tapered organs of her swiftest swimmers and flyers; and (as there is no originating a law or principle of our own) which, in order to succeed, we must adopt or fruitlessly oppose and fail as heretofore. Instead of churning the water's surface with wide dashers, we must take deep hold of it with blades that enter without jarring and lift no loads of it on leaving.

The usual prenomen to steamers wheels is a wrong one, there being no analogy in their action and that of the Indian's paddle. To resemble it the longer axis of the floats or buckets, instead of being parallel with the shaft, should be perpendicular to it, and instead of seeking resistance away from the hull, find it in depth close to it. The *oar* reaches out, but that is to adapt it to human power. Sweeping horizontally through the water at a much greater distance, more power is lost in being imparted to its blade than to that of the paddle. In large wheels the loss is considerable, as the power has to pass to and from the furthest ends of the buckets, whose action is really that of rotating oars—widely different from that of vertical paddles which would dispense with three-fourths of the massive overhanging shafts.

To use the narrow blades of paddles for undershot wheels would be quite as rational as employing the wide planks of the latter for propellers.

A series of experiments was proposed to the administration of President Taylor, and a vessel—the *Water Witch*—was designated for the purpose, but his sudden and lamented death put an end to the design. Conducted under the supervision of the heads of the Coast Survey and Smithsonian Institution, scientific officers of the navy and representations of the Franklin Institute, the result, whether in favor of or against the current wheel, would have been of lasting value, and so will the solution of the problem be whenever and by whomsoever it is accomplished. The government has now another reliable source of information and advice in the National Academy of Science.

In 1855, Professors Bache and Henry, in a letter to the Secretary of the Navy, stated that the proposed experiments "would be of great practical value to the world at large, and of particular advantage to the Navy of the United States." But the time for them had not come. The

reply was, "The Department appreciates very highly the importance of a series of experiments on the best form of propelling blades or paddles for producing, with a given expense of power, the greatest useful effect. It has, however, to regret the want of authority to undertake them, * * * and could not, without inconvenience to the public service, furnish a vessel for the purpose."

It may be that the Navy Department inclines to the opinion of some of its subordinates, that the paddle wheel is all that is wanted, and, so far from ever being superseded, is destined to move the earth's fleets of steamers as long as its prototypes transmits power from running streams to mills and factories. Well, why not then have a practical demonstration of its superiority, which would repay the cost a thousand fold and reflect enduring honor on the Department. The expense can hardly exceed the tithe of a tithe of the pending experiments on steamers and steam. Were it as great it would be true economy to incur it.

There is, of course, an end of the question of propulsion with those who think there is no natural law or principle of velocity in steam vessels, or, if there is, that it has no relation to the form of propelling instruments. If they are right, the highest speed has been attained, and we may sit down and rest satisfied with the common wheel, for there is no risk in repeating the assertion that nothing more is to be got out of it. After undergoing endless variations in details, its dimensions have been swelled to extreme practical limits, and to meet the resistance an unprecedented amount of metal has been put into the shafts—and to what purpose? The largest have been strained to breaking, yet no increase of speed. But it is preaching in the desert to reason with those whose ideas of progress are bounded by the present—who imagine steam fleets of the future are not to surpass those of to-day.

The sole motive in calling the attention of the government once more to the subject, is an abiding conviction of its importance to the Navy. The writer has no selfish object to accomplish—no wish to divert a dollar from the Treasury into his pocket. He has nothing to gain by the adoption of his views, and nothing to lose by their rejection.

E.

New York, October 14, 1865.

For the Journal of the Franklin Institute.

Particulars of Iron Steamships.

Hansa.—Hull built and machinery constructed by Messrs. Caird & Co., Greenach, Scotland. Route of service, New York to Bremen. Commander, Captain Von Santen. Owners, North German Lloyds.

Hull.—Length at load line, 330 ft., do. over all, 360 ft. Breadth of beam, 42 ft. Depth of hold, 26 ft. 2 ins. Depth to spar-deck, 33 ft. 6 ins. Number of decks, 4. Draft at load line, 22 ft. Frame of wrought iron plates, 1 in. to $\frac{5}{8}$-in. in thickness, and fastened with rivets $1\frac{1}{4}$ and $\frac{7}{8}$-inch in diameter, and $3\frac{1}{2}$ inches apart. Floor, shape, **Z**; molded, 6 ins.; sided, $\frac{3}{4}$-in.; apart at centres, 18 ins. Beam ties on each deck. Bulkheads, 5. Rig, barque. Has Davidson's surface condensers. Tonnage, 2830 tons, O. M.

Engines.—Vertical direct. Number of cylinders, 2. Diameters of cylinders, 80 ins. Length of stroke of piston, 3 ft. 6 ins.

Boilers.—Five, tubular. Have water bottoms.

Propeller.—Diameter, 18 ft. Number of blades, 2. Material, cast iron.

REMARKS.—This is a magnificent steamship, well fitted in every respect, and has accommodations for 250 first and second class passengers, and 560 steerage passengers.

—

GERMANIA.—Hull built and machinery constructed by Messrs. Caird & Co., Greenach, Scotland. Route of service, New York to Hamburgh. Commander, Captain H. Ehler. Owners, Hamburgh American Packet Company.

Hull.—Length on deck, 327 ft. Breadth of beam, 40 ft. Depth of hold, 25 ft. Depth to spar-deck, 33 ft. Number of decks, 4. Draft at load line, 22 ft. Frame of wrought iron plates, $\frac{3}{8}$-in. to $\frac{5}{8}$-in. in thickness, and fastened with rivets $\frac{3}{4}$-in. in diameter, and $2\frac{3}{4}$ to 3 ins. apart. Floors, shape, Z ; molded, 6 ins.; sided, $\frac{11}{16}$-in.; apart at centres, 18 ins. Wrought iron plate stringers on two decks. Main deck of iron. Bulkheads, 7. Rig, barque. Tonnage, 2552 tons, O. M.

Engines.—Vertical direct. Number of cylinders, 2. Diameter of cylinders, 72 ins. Length of stroke of piston, 4 ft.

Boilers.—Four, tubular. Have water bottoms.

Propeller.—Diameter, 16 ft. Number of blades, 2. Material, cast iron.

REMARKS.—A first-class vessel, elegantly fitted up in her cabin, saloons, &c., and a model of strength and speed.

—

SCOTIA.—Hull built and machinery constructed by Messrs Robert Napier & Co., Glasgow, Scotland. Route of service, New York to Liverpool. Owners, British and North American Royal Mail Steamship Company.

Hull.—Length of keel and forerake, 360 ft. Length on deck, 374 ft. 6in. Length over all, 400 ft. Breadth of beam, 47 ft. 8 ins. Depth of hold, 23 ft. 10 ins. Depth to spar-deck, 32 ft. 6 ins. Number of decks, 3. Draft at load line, 22 ft. 10 ins. Frame of wrought iron plates, $\frac{1}{2}$ to $\frac{11}{16}$-in. in thickness, and fastened with rivets $\frac{7}{8}$-in. in diameter, and $2\frac{3}{4}$ and $3\frac{1}{2}$ ins. apart. Floors, shape, I ; molded, 10 ins.; sided, $\frac{3}{4}$-in.; apart at centres, 21 ins. Beam ties on all decks. Bulkheads, 6. Two smoke-pipes. Rig, brig. Tonnage, 4136 tons, O. M.

Engines.—Side lever. Number of cylinders, 2. Diameter of cylinders, 100 ins. Length of stroke of piston, 12 ft.

Boilers.—Four, tubular. Have water bottoms.

Water-wheels.—Diameter, 40 ft. 8 ins. Number of blades, 28. Material, iron.

REMARKS.—The framing of the *Scotia* is constructed in a manner securing the greatest amount of strength. The framing of her bow is placed diagonally. Her keel consists of several bars of iron 35 ft. in length, each joined together by long scarps, and is, as a whole, 14 ins. deep by 5 ins. thick. The weight of the iron in this vessel, when launched was 2500 tons, and the finished weight of the hull was 2800 tons. Her masts are 2 ft. 6 ins. in diameter. E. M. B.

Recent Applications of Magnesium. By WILLIAM WHITE.

From the London British Journal of Photography, No. 280.

Last year magnesium was introduced to commerce, and since its introduction, several attempts have been made to convert it from an article of curiosity and amusement into one of utility.

At Bath, last summer, we bought it in wire, and blinded ourselves and dazzled our friends with its brilliant light shortly after it was discovered that combustion was improved by flattening the wire into ribbon, and ribbon has almost superseded wire in the shops.

Magnesium so far has almost exclusively been regarded as a source of light, and the problem is how to burn it to the best advantage.

Lamps.—Assuming that wire or ribbon was the best form, the question narrowed itself to the contrivance of some apparatus which would pay it out at the precise rate of combustion.

Invention moves by easy steps. The first attempts were made by Mr. William Mather, of Salford, and Mr. F. W. Hart, of Kingsland, London, who each produced a lamp in which the wire was delivered by hand from a reel, and guided through rollers, and a tube to the flame of a spirit-lamp, in order to avert the risk of extinction. To this lamp Mr. Alonzo Grant, of Nottingham, affixed clockwork; and with this addition it has met with considerable success.

The risk of sudden extinction was a chief difficulty in the early use of the magnesium light, probably arising from some flaw in the wire—the presence of some foreign matter in its substance. As the manufacture has improved, and the wire has assumed a degree of ductility unknown in samples a year ago, this difficulty has become greatly reduced, and especially in the case of the ribbon, which I have seen burn steadily for half an hour without sign of intermission. Perfect certainty of combustion (dispensing with the spirit-lamp) has been ensured by the use of a double strand of wire or ribbon, it being exceedingly improbable that the flame of both should go out at the same instant, and, in the event of one being extinguished, it would be relit by the other. One of Grant's lamps paying out a double strand has burned for two hours without cessation; and it is only necessary that the reels of magnesium and the clockwork be enlarged to secure a continuous light for any requisite time.

Captain Bamber, R.N., of Clarence House, Jersey, has been making a variety of experiments in order to adapt magnesium to common use in mines, tunnels, and railways. His instrument consists of a mahogony box, about eighteen inches long, containing a series of small wheels (much resembling those of a musical box), and a drum, round which the wire is wound, and from which the burner is supplied at a rate proportionate to the revolution of the drum, whose action is governed by a regulator. The burner is enclosed by a powerful lens or "bull's eye." Captain Bamber exhibited this instrument one night lately at the Paddington Railway Station, and though the thinnest ribbon manufactured was used, the time was easily read off a watch at the distance of 250 yards.

Something yet wanted.—There is manifestly much more to be accomplished in the matter of lamps. We require apparatus whereby a hall or picture gallery can be illuminated for the evening. This, one would say, should be effected by burning the magnesium overhead from the centre of the ceiling, but the disposal of the smoke and ash, consisting of pure magnesia, is the difficulty—a difficulty, however,

which has only to be stated to be met and overcome. Already some ingenious mechanics are tackling it hopefully.

Magnesium Filings.—It is a question whether magnesium in filings has met with due attention. It would not be difficult to deliver a stream of metal as sand from an hour-glass into a jet of gas or other flame, and thus maintain a light with a certainty equal to that obtained by wire and clockwork.

Cui Bono?—"A very curious and beautiful light; but what is the good of it?" asks the practical man. As Franklin met a similar question in the case of electricity, "What is the good of a baby?" Magnesium is a baby, yet though a baby, it has already given some pledges of its manhood. One of its first feats was taking a number of portraits at night with a precision and effect equal to sun-light. This done, it was at once suggested, Why may we not have photographs of caves, catacombs, crypts, mines, and of every dark and wonderful cavity?

Professor C. Piazzi Smyth.—One of the first to put this suggestion to the test was the Scottish Astronomer Royal. Probably all have heard something of the interesting controversy connected with the granite coffer—the *sanctum sanctorum* of the Great Pyramid. It was Professor Piazzi Smyth's great object to bring this mysterious coffer to light, and to dissipate forever all uncertainty about it. This, with the aid of magnesium, he has accomplished. We shall shortly have a volume from his pen descriptive of his researches and conclusions, and illustrated with photographs. Meanwhile he has most kindly allowed copies of his photographs to be exhibited to the Association, and has favored me with a few notes concerning them, which I shall now read:

"*Photography in the Great Pyramid.*—1st. The interior of the Great Pyramid did not prove a good space for developing the excellencies of the magnesium light. The ventillating passages opened by Colonel Howard Vyse in 1837, have been completely stopped up with stones and sand by the Arabs. Hence the air in the interior of the Pyramid has no visible means of being changed or purified, and as the said interior is visited every day through six months in the year by numerous parties of visitors bearing candles, the oxygen is so deficient, and the carbonic acid so abundant, that my surprise is that the magnesium burnt at all. It did burn, but in a languid sort of way, and the smoke it threw off remained suspended in the motionless air for twenty hours or more, so that only one picture could be taken in twenty-four hours. If a second was attempted, the illuminated smoky air intervening between the camera and the object desired to be pictured was the only result on the photographic plate.

"2d. My object was not pictorial or artistic photography (of which I have therefore nothing to show), but the application of photography to certain disputed and special parts of the interior of the Pyramid for the sake of scientific examination and measurement; and those objects *were* obtained, notwithstanding all the drawbacks of the place, which really seemed combined to frustrate the merit of the light.

"3d. One example or success is presented in the granite coffer, in

the king's chamber of the Great Pyramid. According to the theory of the late Mr. Taylor, that coffer was a primeval measure of capacity, from whence is derived the hereditary Anglo-Saxon wheat measure, called the quarter, of which coffer it is the fourth part. Whilst, however, we know by Act of Parliament how many cubic inches are contained in four quarters, English, there has been much doubt as to the cubical contents of the granite chest of the Pyramid. The measures of the French Academy, in 1799, made it 6300 cubic inches greater than several English travelers had declared it to be, though they again by no means agreed with each other in subsidiary details. Now, however, by means of the magnesium light, we have a series of photographs of this coffer, with a system of measuring rods fastened about it,* showing the inside and the size outside, and, finally, the cubical contents being summed up, prove that the remarkable granite vessel *is* a measure of capacity, equal, with almost mathematical accuracy, to four quarters, English."

A Revealer of Colors.—A peculiarity of the magnesium light is that it leaves colors unaffected; that is, it displays them as in sunshine. This may be verified with agreeable effect by burning a piece of wire at night in a garden or conservatory, when it will be found that greens and blues, yellows and whites, reds, violets, and purples appear with perfect distinctness. This fortunate quality has led to the employment of the light by dyers and silk mercers as a ready means of settling questions as to shades of colors, either at night or in foggy weather.

Alloys.—A variety of magnesium alloys has been made, but none so far with any obvious excellence. Some experimentalists have had trouble in preventing the combustion of the molten magnesium. An easy way of getting over this difficulty is by first melting, say the copper, and then with pincers or otherwise holding the piece of magnesium underneath its surface until it is dissolved. By practiced and dexterous handling, molten magnesium is safely managed in closed vessels, but any one may try his hand at alloys by the method described.

An alloy of lead and magnesium burns very well; but the best combustible result is obtained by the combination of zinc and magnesium. Alloys with zinc in the proportions of 5, 10, 15, and 20 *per cent.* are readily converted into wire, and burn steadily, giving out more smoke however, and the light exhibiting less actinic power.

For common pyrotechnic purposes these combinations of zinc and magnesium promises admirably. Reduced to powder they supply a brilliant ingredient for rockets; and in the shape of wire, they form a simple and efficient firework, cheaper, if less dazzling, than magnesium alone, and quite worthy of Guy Fawkes' day.

Captain Bolton's Opinions and Experiments.—To the utilization of magnesium no one has brought such experience and such resources as Captain Bolton. As is well known, he devised the oxyhydrogen signal

* The application of the measuring rods was a happy idea worked out by Joseph Sidebotham, Esq., of Manchester. He supplied Professor Piazzi Smyth with some large slices of an old organ pipe of Queen Anne's time, as the most unexceptionable stuff—thoroughly seasoned wood wherewith to make trustworthy scales.

apparatus introduced to H. M.'s service some three years ago. The credit attached to this success would have tempted many a man into the position of an obstructive, but Captain Bolton having arrived at the conviction, based upon actual experiment, that the magnesium light possessed all the necessary attributes for a perfect naval and military signal light, equally with the electric and lime light, and with decided superiority over them in the grand requisite of handiness, he at once avowed his conviction, and set to work to apply its powers to the best advantage.

In the first place, in conjunction with Captain Colomb, he has succeeded in introducing magnesium powder into signal lights for use in the mercantile marine. These lights are intended to burn on the port or starboard sides of vessels entering port during thick or foggy weather. They last 3, 5, or 8 minutes, and longer lights from 12 to 15, and are distinctly visible at a distance of eight miles. The cost is trifling.

The Mercantile Marine Association of Liverpool, have lately recommended that a powerful red light be made as the signal for danger at night. This recommendation Captain Bolton and Captain Colomb have met, again, by the use of magnesium in powder. They have prepared a red light to burn about 15 minutes at a cost of 1s. 6d. It is visible in clear weather at a distance of 10 miles. The signal is now under consideration by the Association.

A greater interest, however, belongs to Captain Bolton's efforts to supersede the oxyhydrogen light by the combustion of magnesium in simplicity, in wire or ribbon. His apparatus for this purpose is not yet complete, and until it is it would be unfair to him to prejudice it by description. Suffice it to say, that he has succeeded in consuming or suppressing the smoke, and with a few more adjustments will accomplish clipping off the ash which gathers on the point of the burning strand of magnesium, and sadly dims its glory.

With all imperfections, Captain Bolton has found it easy to signal with magnesium from Shoeburyness to the Great Eastern, eight miles off; and from Portsmouth to St. Catharine's Downs, Isle of Wight, a distance of sixteen miles.

Supposing Captain Bolton should fully attain what he purposes, it will lead to the employment of magnesium in all the ships and lighthouses of Europe. Rid magnesium of its smoke and ash, and there is no light to compare with it in other respects.

Magnesium in America.—The manufacture of magnesium has been commenced in Boston, and from the men in Massachusetts, who are said as babies to lie awake and scheme improvements and patents in the construction of cradles, we are likely to hear of some novel applications of the metal. If the contest in which they were engaged had not so happily ended, we should have learned ere this a good deal about the utility of magnesium in war. We were startled last February in *The Times* and other papers, that blockade-running was about to receive an unexpected check, for it had been found possible to remove the veil of night by the blaze of magnesium fire. In a rough way it

may be said, that to us in England novelty is a prejudice to be overcome, but to Americans, novelty is a recommendation.

Other Uses for Magnesium.—All our talk has been of magnesium as a source of light, but surely it will be found capable of other applications. It is, perhaps, the most abundant metal in nature. It rolls in the sea, and forms vast tracks of land. If, as some say, everything in creation bears reference to man, and was designed for his use, what a future there is for magnesium! Sir Humphrey Davy was the first to give the hint of its existence, nearly sixty years ago; it is time that Birmingham converted that hint to practical purpose.

On Chemistry Applied to the Arts. By Dr. F. Crace Calvert, F.R.S., F.C.S.

From the London Chemical News, No. 247.

(Continued from page 248.)

Lecture V.*

Bile, its properties. *Blood*, its composition and application in the refining of sugar and manufacture of Albumen. *Albumen*, its application to calico printing and photography. *Milk*, its composition, properties, falsification, and preservation. *Urine*, its uses. A few words on putrefaction.

In this lecture we shall examine the composition of the various liquids secreted in the human body and in those of animals, and the uses to which these fluids are applied in arts and manufactures.

Bile.—The composition and appearance of bile vary greatly in different animals. Usually it is a yellow, green, or brown thick fluid, with a marked alkaline reaction, and containing about 14 per cent. of solid matter, the most important constituents of which are, in human bile, mucus, two coloring matters, one yellow, (*cholepyrrhine*,) the other green, (*biliverdine*,) sugar, albumen, two organic acids, (*cholic and choleic*,) combined with soda, oleate and margarate of soda, a non-saponifiable fatty matter, (*cholesterine*,) and several mineral salts. The two most interesting substances in bile are choleic acid and cholesterine, which, when produced in undue proportion, give rise to those calculi, the passage of which through the biliary duct is so dangerous and painful. One of the most valuable papers published of late is that of Mr. G. Kemp, in the *Transactions* of the Royal Society, on the conversion of the hepatic bile into cestic; thus he has shown that as the former is secreted by the liver, and arrives by the biliary duct into the gall bladder, it is there converted into cestic bile by means of a special fermentation induced by a mucus secreted in the walls of the gall bladder. It is believed by most physiologists that the principle function of bile is to neutralize the acid fluids resulting from digestion in the stomach, as they enter the small intestines, rendering them better adapted for their sojourn there, and also facilitating their fermenta-

* This lecture was No. VI. when the course was delivered, but the present order of publication has been adopted, as bringing the whole subject more systematically before the reader.

tion, one of the most important phenomena of digestion. The employment of bile as a scouring agent has much diminished of late years, owing to the substitution for it of benzine and Sherwood spirit.

Blood.—The study of this all-important fluid is most interesting in a physiological point of view, for the twenty-seven pounds of blood (the average amount in an adult) which travels through the whole of the human frame in about three minutes, fulfils three distinct functions, viz: it carries the various elements of food, as modified by digestion, into the different parts of the body requiring them; it helps to remove from the system those substances which have fulfilled their required functions in it, and which have been rendered useless by the wear and tear of life; and it conveys through the system the heat generated by the oxidation, through respiration, of the substances which have been absorbed during digestion, as well as those which have performed their part in the human economy, and require to be removed therefrom. It will, therefore, be easily understood that blood must be a complicated fluid; and the following table will give an idea of the truth of this assertion:

1000 parts of blood.

130·85 of clot.	Fibrine,	2·95	130·85
	Globules,	125·63	
	Hematosine,	2·27	
869·15 of serum.	Water,	790·37	869·15
	Albumen, Soda,	67·80	
	Phosphate of Soda, Lactate of Soda, Carbonate of Soda, Chloride of Sodium, " of Potassium, Carbonate of Lime, " of Magnesia, Ammoniacal Salts, Phosphate of Lime, " of Magnesia, Sulphate of Potash, Fatty Acids, free or combined, Cholesterine, Lecithine (phosphuretted fat),	10·98	
1000·00	Ceribrine, or nitrogenated fat,		1000·00

It will facilitate our study of this complicated fluid if we class the various compounds existing in it under six different heads. First, if blood, immediately after being drawn from an animal, is whipped with a birch rod, the ends of the twigs will have hanging from them a stringy mass, which, after being well washed, is grey and elastic, and is called *fibrine*. Secondly, if the blood so treated is mixed with a solution of sulphate of soda of specific gravity 1·16, and the whole thrown on a filter, the *corpuscles* and the coloring matter called *hematosine* will remain on the filter, and these substances with the fibrine form, as shown in the table, the clot of blood. Further, if the matter left on the filter is treated with concentrated acetic acid, the coloring matter is dissolved, and the corpuscles are left as yellow discs. Thirdly, on boiling the fluid which passes through the filter, albumen is coagulated

and can be easily separated, leaving water and a few saline substances which are easily separated by evaporating the liquid portion. Allow me now to add a few remarks on some of the substances above mentioned. Fibrine represents the fibrous or muscular part of animals, but has no direct application in manufactures. The blood corpuscles in man are ellipsoid discs, containing the coloring matter of blood. The most interesting fact connected with the latter is that it is united with a compound containing iron; and although iron does not appear to be an integral part of the color, still its presence appears essential to the existence of the color itself. The external part of the discs is composed of fibrine, whilst the interior contains an albuminous fluid, (which differs from the albumen of the serum in the fact that it is not coagulated by heat,) and which is called globuline. The relative proportion of fibrine, globuline, and hematosine vary considerably in different individuals, according to health, age, and sex, and even during the process of digestion. When blood is examined under the microscope, large colorless globules are found to float with those just described. Dr. William Roberts, of Manchester, who has examined the corpuscles of blood, has observed that when they are dipped into a solution of magenta, they assume not only a pink color, but that the nucleus of the disc acquires a much deeper shade. Further, that on the sides of the disc there are small projections which he calls pullulations, and which acquire a much deeper tint than the remainder of the discs when plunged into the magenta solution. Another curious fact lately observed by M. Pasteur is that if blood is kept for several weeks in a cold situation, air being excluded, the corpuscles disappear, and are replaced by myriads of beautiful red well defined crystals. Lastly, there is a slight difference of composition between arterial and venous blood.

	Arterial.	Venous.
Carbon,	50·2	55·7
Nitrogen,	16·3	16·2
Hydrogen,	6·6	6·4
Oxygen,	26·3	21·7
	99·4	100·0

It is strange that, while blood is so extensively employed on the Continent, in various branches of manufacture, that in Paris 2000 tons of blood are used by sugar refiners alone, hardly any such application of this fluid is made in our own country. It appears to me that the explanation is to be found in the fact that on the Continent beasts are generally slaughtered in public abattoirs, by which means many of the refuse matters can be collected with advantage, and without being spoilt or polluted by unscrupulous persons, whilst in this country, where animals are slaughtered in innumerable private slaughter houses, the difficulty and expense of collection, together with the absence of guarantee of quality, render the successful use of blood on a large scale impracticable. There is an additional advantage in the system of public abattoirs, which I cannot help noticing *en passant*, viz: the guarantee thereby obtained that the public food is not furnished from

diseased animals. The only employment of blood in its integrity in this country is as an article of diet, and to some extent in the manufacture of prussiate of potash. The serum of blood is sometimes used in England, as well as on the Continent, as one of the substances essential in the process followed to communicate to cotton the magnificent color called "Turkey red."

Albumen, (blood.)—The employment of this substance in the art of calico printing is of comparatively recent date, as it is chiefly due to the introduction of the tar colors and pigment styles into that art. To fix colors with this albumen (or that of egg) it is only necessary to dissolve in a gallon of water several pounds of albumen and gum Senegal, adding a little tar color, such as magenta, &c., or a pigment, such as ultramarine blue; these mixtures are then printed on the cotton fabric, and the color fixed by the coagulation of the albumen under the influence of high pressure steam. But the quantity of albumen used for this purpose has greatly decreased of late years, owing to the introduction of tannin by Mr. Charles Lowe and myself, Messrs. Roberts, Dale & Co., and Mr. Gratrix, and also that of the arseniate of alumina by Mr. W. A. Perkin. The substitution of blood albumen for that of egg is chiefly due to Messrs. Robart, Roger & Co., who, I believe, prepare it by separating carefully the serum of blood from the clot, adding to it a small quantity of alum to separate any coloring matter that may be mixed with it, and evaporating the water of the serum by a current of air heated to 100°, which leaves the albumen in the form of yellowish scales, freely soluble when placed again in contact with water. The most abundant source of albumen, however, is the white of egg, and, therefore, let us glance at a few facts connected with this substance, doubly important as an article of manufacture and as one of food. To give some idea of the extensive use of eggs, I may state that in Paris there are annually consumed 178,000,000 eggs, weighing 28,000,000 lbs. The composition of a hen's egg may be stated as follows:

Shell, ...	11·5
White, ...	58·5
Yolk, ...	30·0
	100·0

The following are the respective compositions of the yolk and white:

Yolk.		White.	
Water, ...	51·47	Water, ...	86·34
Vitelline, ...	15·76	Albumen, ...	12·50
Oleine, Margarine, Cholesterine, . . .	28·97	Membrane, . . .	0·50
Phospho-glyceric acid, .	1·26	Phosphates, Chlorides, &c.,	0·66
Coloring matters, . .	1·20		100·00
Mineral salts, . . .	1·34		
	100·00		

An egg may be considered as consisting of four parts, the shell, membrane, white, and yolk. The shell is composed of carbonates of lime and

magnesia, phosphate of lime, and oxide of iron, the whole bound together by a nitro-sulphuretted substance. The presence of sulphur in this substance, as well as in albumen, explains why eggs give off sulphuretted hydrogen when boiled. The membrane lining the shell is also a nitro-sulphuretted substance, much resembling in its composition that of horn. I have already had occasion to speak of the interesting composition of the yolk of egg, when mentioning its application in the glove manufacture, and on that occasion I drew your attention to the remarkable substance called vitelline, and to the peculiar nature of the fats contained in yolk of eggs, but more especially to the phospho-glyceric acid, and attributing to them the peculiar properties imparted to leather through their use. The white of egg chiefly consists, as the above table shows, of a substance called albumen, which you will remember is found in blood, and I may add that it exists in the sap of all plants. Albumen is a fluid of an alkaline reaction, soluble in water, and coagulates at 160 degrees when undiluted, but when dissolved in water the temperature at which it coagulates is raised according to the extent of its dilution. Albumen gives a precipitate with all metallic salts, but one of the most characteristic and delicate tests for albumen in solution is bichloride of mercury or corrosive sublimate. In fact, albumen is the best antidote known to the action of this violent poison when taken internally, as was proved by its saving the life of an eminent chemist (Baron Thenard) in 1825. All acids, except phosphoric and acetic, precipitate albumen from its solutions, but that which separates it with the greatest nicety is nitric acid; when placed in contact with hydrochloric acid for a few hours, it assumes a very beautiful purple color. When albumen is placed in shallow vessels, and then stored in a chamber where air at 100° is allowed to circulate, the water evaporates and leaves the solid albumen in the form of yellowish, semi-transparent scales, which, strange to say, will, if kept dry, resist putrefaction for any length of time, although in its liquid form the large amount of nitrogen it contains renders it highly putrescible. It is this solid albumen which is used by calico printers, as it is easily dissolved in water, and rendered applicable to their purposes. Albumen is often used in manufactures to clarify fluids. In some instances the albumen in solution is added to the fluid and carried to the boil, when the dissolved albumen coagulates, and in falling through the fluid carries with it mechanically the matters in suspension, when it is only necessary to decant the clarified fluid. In others it is added at natural temperature, as in the case of wines, where the tannin, alcohol, and acids are the agents which coagulate the albumen. Albumen was first applied to photography by Niepce de St. Victor, in the following form: He mixed together intimately ten fluid ounces of distilled water with the white of ten fresh eggs; to this he added 200 grains of chloride of sodium or chloride of ammonium. The whole was well shaken in a bottle for about ten minutes, and then allowed to stand. All that was then required was to decant the clear liquor, and apply it to the surface intended to receive the photographic image. (Here the lecturer shortly described this photographic process,

and alluded to the recent application of the light resulting from the combustion of magnesium wire, manufactured by Messrs. J. Mellor & Co., of Salford, showing its applicability to photography by using this light to take photographs during the lecture, stating that the cost was only a few pence.) A great many attempts have been made to preserve eggs from decay, the most successful of which have been those of Le Maison Cormier du Mans, who covers the eggs with an impermeable varnish, packing them in sawdust, so that the egg shall always rest on one end. Another process is that of immersing the eggs in lime water. Lastly, the whole of the egg has been emptied out of the shell and evaporated to a solid mass. I must not conclude the subject of the albuminous and vitelline substances without calling your attention to the following table, which will give an idea of the different albumens and vitellines which Mr. E. Fremy has succeeded in isolating and characterizing:

EGGS OF BIRDS.

Albumen	coagulated by heat,	All these substances are characterised by containing sulphur.
Eudophacine	" " "	
Albumen	" " "	
Meta Albumen	" " "	
Exophacine	" " "	

EGGS OF FISHES.

Ray,	Ichthine,	All these substances are characterised by containing phosphorus.
Goldfish, Carp,	Ichthidine,	
Salmon, Turtle,	Icthuline and Salmonic acid, Eurydine.	

(To be continued.)

On the Supposed Nature of Air prior to the Discovery of Oxygen.

By GEORGE F. RODWELL, F.C.S.

From the London Chemical News, No. 297.

Continued from page 254.

XIII. Boyle's Second Pneumatical Treatise.—It will be remembered that Boyle's first series of "Physico-Mechanical Experiments Touching the Air" appeared in 1660. In 1661 he presented his air pump to the Royal Society, and during the five following years he undertook no lengthy pneumatical research. Occasionally, however, during this period we find mention of vacuum experiments shown by him at meetings of the Royal Society;* but now that the air pump had passed out of his possession, it is obvious that he had not the same facilities as before for carrying out a research of any magnitude.

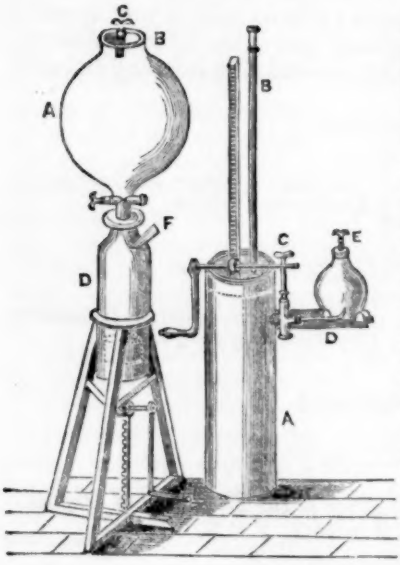
Inasmuch as during these five years Boyle heard of only two air pumps having been constructed, and of only one or two new vacuum experiments, he determined to construct a new air pump, and to proceed further with his former experiments. With the assistance of Hooke he constructed an air pump in 1666, of different form from the first one, and in some respects superior to it. In order that the two

* These experiments have been detailed in the preceding paper.

may be compared, we have placed them side by side in the accompanying wood cut. Fig. 1 represents the instrument constructed in 1659, which was employed for the first series of experiments (described in the fourth and fifth of these papers); Fig. 2, the second air pump constructed in 1666, and employed for the experiments detailed below.

A (Fig. 1) represents the receiver, a globe of glass of the very large capacity of "thirty wine quarts;" it had a circular opening above, into which was cemented a brass ring B, closed by an accurately turned disc of brass, which fitted into it, and could be readily removed for the introduction of objects to be experimented upon. The disc was perforated, and the orifice closed by a ground brass stopper C, by turning which, bodies within the receiver connected with it by a string could be moved when the receiver was exhausted. The lower part of the receiver communicated directly with the cylinder D, and was furnished with a stopcock E. A solid piston moved by a rack and pinion, worked within the cylinder. In the upper part of the cylinder there was an orifice, into which the brass stopper F, fitted air tight; this served as a valve. Suppose the piston at the top of the cylinder, the stopper F, in its place, and the stopcock E, closed, the piston is drawn to the bottom of the cylinder, (that is to say, to the position shown in the figure,) and E is opened; immediately part of the air in the receiver rushes into the vacuous space in the cylinder; E is then closed so as to shut off communication between the cylinder and receiver F is removed, and the piston forced to the top of the cylinder, the air within the latter escaping through the valve orifice; F is now replaced, and the previous operation repeated until the receiver is exhausted.

Fig. 1. Fig. 2.



A (Fig. 2) represents a cylinder of metal, furnished with a piston moved by rack and pinion. The valve (F, Fig. 1,) of the 1659 air pump was in this transferred to the piston, which was perforated, and the orifice was closed by a brass stopper with a long handle B, for the purpose of placing it in the orifice when the piston was at the bottom of the cylinder. A pipe, provided with a stopcock C, issued from the side of the cylinder, and, passing along the air pump plate D, terminated beneath the receiver E. The piston being at the bottom of the cylinder, the stopper in its place, and the stopcock C closed, the piston is raised to the position shown in the figure, and C is opened; immedi-

ately air from the receiver flows into the vacuous space in the cylinder; C is now closed, the valve opened by raising B, and the piston forced to the bottom of the cylinder. The stopper is then replaced, and the previous operation repeated until the desired effect is produced.

The advantages of Boyle's second air pump over the first were (*a*) the diminished size of the receiver as compared with the pump barrel, whereby the exhaustion was rendered more complete, and was more quickly obtained; and (*b*) the introduction of an air pump plate, whereby the use of a globular receiver was avoided, and bodies to be experimented upon, instead of being suspended, could be placed upon a level surface. and thus during the working of the instrument did not multiply its smallest motion by swinging, as was the case when supension was resorted to. The air pump plate was of iron, and the receiver was cemented to it, by which means Boyle managed to retain a receiver well exhausted for a length of time. The vacuum produced by the second pump appears to have been very good, of which we shall have several opportunities of judging as we proceed; the chance of leakage, moreover, was less than in the first pump. Nevertheless, the 1666 instrument had its disadvantages; like its predecessor, it fell short of Otto Guericke's pump in one respect—the valves were worked by the hand, which rendered the operation of pumping comparatively slow; it was also inferior to the 1659 air pump in one respect—the pump barrel was placed in a vessel of water, and the piston always worked under water, which not only rendered the instrument cumbersome, but not unfrequently led to water finding its way into the receiver. In describing his first air pump, Boyle mentions as a special reason why he endeavored to construct an instrument different from Otto Guericke's, that he desired to avoid the necessity of having it work under water. It is curious, therefore, that in this second pump, after further experience, he adopts that which he had previously considered so great a disadvantage.

In 1669 Boyle published a volume* containing an account of his new air pump, and of a number of experiments made therewith. It is written in the form of a letter, and is dated March 24, 1667. This second pneumatic treatise cannot be read with the same amount of interest as the first, for there is not only less original matter, but many of the experiments are mere repetitions of those described in the former treatise, and for the most part tend to strengthen results previously obtained, and to prove or disprove conjectures; but be it remembered we depreciate this work only as compared with the first treatise, for no research on pneumatics comparable to it had appeared since the first research of the same author, which excelled it.

We will briefly consider the more important experiments described in the second treatise:

* "A continuation of new experiments. physico-mechanical, touching the spring and weight of the air, and their effects. Part 1. By the Honble. Robert Boyle, F.R.S. Oxford, 1669."—Although dated 1669, this work was published in the latter part of 1668, as appears from the copy in possession of the Royal Society, on the title page of which is written. "Presented from ye author to ye R. Society, Novemb. 30, 1668."

Experiment 1.—A phial of about five ounces capacity was partially filled with mercury; a tube four feet long open at both ends was then cemented air-tight into its neck in such a manner that it reached nearly to the bottom of the phial, and consequently passed beneath the surface of the mercury; it is obvious that when the air within the phial expands, it must cause the mercury to rise in the tube. The arrangement was placed under a tall receiver, which was exhausted. When the air vessel was very large, the mercury rose no higher than twenty-nine inches, (Experiment 2;) neither did variations in the diameter of the tube alter the case, (Experiment 3.)

Experiment 4.—Water was substituted for mercury in the above arrangement; on exhausting, it was ejected forcibly from the top of the tube by the expansion of the air in the phial, the "fountain in vacuo" of our present works on pneumatics.

Experiment 8.—A bladder one-fourth filled with air was securely closed, and introduced into a receiver; it was loaded with a weight of 28 lbs.; on exhausting, the expansion of the air within the bladder raised the weight.

Experiment 11.—A tube 50 inches long was bent at a right angle; its upper portion was placed in air-tight connexion with the receiver, while its lower end dipped into a vessel of mercury; on exhausting, mercury rose to a height of 29 inches in the tube. This arrangement was afterwards applied by Hauksbee to measure the degree of rarefaction obtaining in a receiver, and is now known as the "barometer gauge."

Experiment 12.—In order to prove that the height to which a liquid is raised in a vacuous tube, by the pressure of the external air, depends upon the specific gravity of the liquid, Boyle procured a glass U tube, the length of each limb of which was 42 inches; it was inverted, one limb was caused to dip into mercury, the other into water, and the upper part of the tube was placed in connexion with the receiver; on exhausting until the water had risen to a height of 42 inches, the mercury in the other limb was found to have risen 3 inches; when strong brine was substituted for mercury, the brine column stood at 40 inches, a solution of potash stood at 30 inches, the water column being in each case at 42 inches.

Experiment 13.—Into a pint bottle Boyle poured mercury and water, so that they together partially filled it; two upright tubes, open at each end, were then cemented side by side into the neck of the bottle; one reached beneath the mercury surface, and the other beneath the water surface; the arrangement was placed under a receiver; on exhausting, it was found that when the elasticity of the air in the phial had raised the mercury to a height of 1 inch in the one tube, the water had risen to a height of nearly 14 inches in the other; when the mercury was at 2 inches, the water was at nearly 28 inches.

Experiment 14.—A short tube closed at one end was filled with mercury, and inverted into a vessel of mercury; a longer tube was filled with water, and inverted into a vessel of water; both vessels with their tubes were placed under a tall receiver; on exhausting, it was found

that when the mercury in the tube had fallen to within 3 inches of the stagnant mercury, the water column stood at 42 inches; with the mercury at 2 inches and 1 inch respectively, the water fell to 28 and 14 inches.

Experiment 15.—In order to determine the exact height to which water can be raised by a suction pump, the air pump was conveyed to the roof of a house, and a tube bent twice at a right angle was placed in air-tight connexion with the receiver. The longer limb of the tube was 35 feet long, and its lower end was caused to dip into a vessel of water standing on the ground. On exhausting, the water rose to a height of 33½ feet, the mercury column in a barometer standing at 29 inches. This experiment, together with several of the above, prove the great efficiency of the 1666 air pump.

Experiment 16.—In order to ascertain whether air contributes to the elasticity of solid bodies, a piece of whalebone, having a weight attached to one end of it, was placed in the receiver in such a manner that it supported the weight just above the air pump plate. On exhausting, no alteration in the weight was observable.

In the 17th experiment Boyle describes the way he adopted to determine the degree of exhaustion of a receiver. In his first attempts he placed a securely closed bladder containing a small quantity of air in the receiver to be exhausted, and considered the exhaustion good when the bladder was fully inflated. He afterwards measured the exhaustion by a small U tube, closed at one end, which was filled with mercury, and a small bubble of air then passed into the closed end. The tube was placed into a vessel to be exhausted, and the rarefaction judged of by the expansion of the bubble of air.

Experiment 18.—"About an easie way to make the pressure of the air sensible to the touch of those who doubt it." In order to effect this, Boyle constructed a small brass receiver of the form of a truncated cone, open above and below; the upper orifice was 1¼ inch diameter, and the lower, which stood on the air pump plate, 2½ inches. "The person," he writes, "that would not believe the pressure of the air to be near so considerable as was represented, was bidden to lay the palm of his hand upon the upper orifice, and being ordered to lean a little upon it, that so the lower part of his hand might prove a close cover to the receiver, one exsuction of the air was made by help of the pump, and then upon the withdrawing of the greatest part of the pressure of the internal air, that before counterbalanced that of the external, the hand being left alone to support the weight of the ambient air, would be pressed inwards so forcibly that, though the stronger sort of men were able (though not without much adoe) to take off their hands, yet the weaker sort of tryers could not do it, (especially if by a second suck the little receiver were better exhausted,) but were fain to stay for the return of air into the receiver to assist them."

Experiment 31.—A magnet was loaded with the utmost weight it could carry. It was then introduced into a receiver. On exhausting, the weight still continued to be supported.

Experiment 32.—A small brass syringe was taken, and the piston

forced to the bottom of it; the orifice of the syringe was then closed securely. When the piston was raised, great resistance was felt, and on releasing it the pressure of the air of course caused it to return to its former position. It was now placed in a receiver, and the piston handle placed in communication with the stopper of the receiver by a piece of string, so that by turning the stopper the string was shortened, and the piston consequently raised; when the receiver was exhausted, the piston was easily raised to the top of the syringe, when it was kept in that piston, and air admitted; the piston was immediately impelled to the bottom of the syringe, and the string which held it was broken. The above experiment was varied by suspending a closed syringe in the air pump receiver by its piston rod, and attaching a weight to the barrel not sufficient to draw it down—in other words, not sufficient to overcome the pressure of the air on the area of the piston. On exhausting, the barrel immediately descended, and when air was admitted, it rose to its former position, dragging up the weight with it.

Experiment 34.—A syringe was placed in a receiver in such a manner that its piston could be raised when the receiver was exhausted; a glass tube was fitted to its nozzle, and its lower orifice caused to dip into mercury. On exhausting and raising the piston, the mercury was observed not to follow it, but when air was admitted, it immediately rose to the piston.

Experiment 35.—A cupping glass was attached to the palm of a person's hand by the usual method; the hand was then made to act as a cover to a small receiver. On exhausting, the cupping glass fell down.

Experiment 40.—Some small feathers were detached from the top of a tall receiver; before exhaustion they fell slowly, and wavered in their course; after exhausting the receiver, they fell "like a dead weight."

Experiment 43.—Sugar was submitted to friction in an exhausted receiver, and was found to emit light as readily as in air.

Experiment 45.—In order to ascertain whether heat could be produced by friction in an exhausted receiver, a concave piece of brass was fixed to the air pump plate, a convex piece of the same metal was connected with a rod which passed air-tight through the cover of the receiver, and could be turned by a handle. When the two surfaces were rubbed together in vacuo, a considerable amount of heat was found to be produced.

Experiment 48.—Quicklime was slaked in an exhausted receiver, and heat was found to be produced as readily as when it was slaked in air.

With this experiment we conclude our notice of Boyle's second pneumatical treatise. There are altogether fifty experiments. Of these we have noticed the most important, omitting those which are only slightly modified forms of experiments described in the former treatise.

Moving Photographic Figures. By A. CLAUDET, F.R.S.

ILLUSTRATING *some phenomena of vision connected with the combination of the stereoscope and the phenakitiscope by means of photography.*

From the British Journal of Photography, No. 280.

From the beginning of photography it must have struck many of those who were acquainted with the phenomenon illustrated by the phenakitiscope invented by Plateau, that photography could produce with advantage the series of pictures used in that instrument, on account of their possessing a greater degree of accuracy than when made by hand. At a later period, when the stereoscope had become popular from its application to photography, there must have been a still stronger incitement to make use of that process to produce binocular pictures for the phenakitiscope, in order to combine the stereoscopic effect to the illusion of moving figures elicited in the phenakitiscope. For example: If a number of binocular photographic pictures were taken of a machine in various consecutive stages of its motion, these pictures, applied to a phenakitiscope, would give a complete illusion of the machine in perfect relief and in its full action.

Binocular pictures of persons dancing, fencing, or boxing, of acrobats at their wonderful feats, of boys playing at different games, all in the various stages of the action of each sport, representing consecutively the whole performance—such pictures might have been supposed to be invaluable to exhibit the stereoscopic illusion of persons in the real action of life. Therefore, the solution of such an interesting problem was capable of exerting the emulation and the ambition of many ingenious and scientific minds.

Among those who undertook the task, M. Duboscq, the eminent optician, of Paris, was the one who attained the greatest success. He had fixed the two series of binocular photographs on two zones of the revolving disk of the phenakitiscope one above the other, and by means of two small mirrors, placed each respectively at the inclination capable of reflecting the two zones, on the same horizontal line, from whence the images could each separately meet the axes of each of the two prismatic lenses of the stereoscope, each eye, during the revolution of the disk, had separately the perception of one of the series of photographs, each showing the perspective of one eye, and the stereoscopic effect of figures in motion was consequent.

M. Duboscq gave another form to the phenakitiscope. Instead of the vertical original revolving disk of Plateau, he employed a cylinder revolving on its vertical axis, and he placed on two inside zones of that cylinder, one above the other, the two series of photographic pictures between the slits through which the eyes can see the pictures, and by means of two mirrors, as in the other apparatus, each series was reflected on its respective lens through the cylinder, and the stereoscopic effect was produced in combination with the phenakitiscopic effect.

However, these two attempts of M. Duboscq did present a few imperfections, which we are going to explain. In the revolving disk the two series of pictures do not move with the same velocity, on account of their being placed on two zones of different peripheries, and this

produces a sort of confusion and distortion in the representation of the object during its movement. The same defect exists in Plateau's phenakitiscope from the perception of its single series for the top and bottom parts of the figures (owing to the cause explained), revolving in different velocities, not being impressed on the retinæ during the same time, and the blank spaces between the pictures, being larger for the top than for the bottom part, giving a stronger sensation of void during the visual perception of the pictures.

In the revolving cylinder this defect does not occur, but the picture, being considerably curved like the cylinder, is a most unfavorable disposition for examining them in the stereoscope. However, M. Duboscq's contrivances are very ingenious, and in his attempt he succeeded, at all events, in proving the possibility of solving the problem.

About that time I had also turned my attention to the subject, and found some difficulty in obtaining at once the phenakitiscopic and the stereoscopic effects, in avoiding the defects I have alluded to. However, as I am far from considering the case to be quite desperate, I intend to resume my researches as soon as I have leisure to do so. What gives me some hopes of success is the attempt I made years ago. The result has been incomplete and imperfect, but if I have not succeeded in obtaining at once the motion and relief, I have gone so far as to show figures which appear really to be in motion, and preserving all the correctness and distinctness of the photographs.

My ambition to obtain the stereoscopic effect with the movement of the figures having (I hoped only momentarily) been foiled, and not being satisfied with partial success, I did not like to publish an incomplete attempt, and for this reason, till now, kept it only for the curiosity of a few intimate scientific friends. But years are passing away swiftly, and as I do not feel, at my period of life, that I can reckon upon endless time and inexhaustible activity to complete many labors, I did not like to let another meeting of the British Association pass without availing myself of the opportunity of bringing before this annual scientific congress a very simple contrivance which (if I do not later succeed in solving the whole problem) will, at all events, perhaps, call the attention of others to the subject, and induce them to try their hands and brains at its solution.

This is one of the many instances of the advantages of the British Association. Once a year all the branches of science of the world are brought together to show the progress made, and point out the progress to be made. All the devoted followers of those sciences consider that they are obliged to contribute their mite, however small it may be, to increase the general interest of the meeting, and to awaken the desire for further improvements and new discoveries.

As it will be seen by the instrument I submit to the meeting, it is very easy to obtain the illusion of moving figures, but without stereoscopic effect. In this instrument, my first object having been only to try the principle, I have constructed it in the simplest form capable of showing the motion of the figure, and I have found that only two pictures are sufficient to elicit the phenomenon, although the illusion of

reality suffers from the abruptness of two extreme movements, and from the deficiency of intermediate positions.

But nothing is so easy as to employ eight different pictures in as many different stages of action, and with this number of pictures the effect will be sufficiently complete. For this, having placed in the stereoscope two separate cubic frames, revolving independently on the same horizontal axis, I have only to fix on their four sides at right angles two sets of four pictures, making eight pictures, which are made to pass in consecutive order, one after the other, before the lenses of the instrument, and the figure will appear to assume consecutively eight different stages of the whole action. The instrument in its simple state, with only two pictures, will suffice to illustrate the principle, and, at the same time, to elicit some curious phenomena of the perception of vision.

It is known that the retina has the power of retaining for a short time the impression or the sensation of the image which has struck it. Now, availing myself of this property, I have constructed the instrument in such a manner that, by means of a slide with one hole, I can, by moving it rapidly in a reciprocating horizontal direction, shut one lens while the other remains open; and in continuing that motion, while one eye sees one of the two pictures, the second eye cannot see the other picture.

Now, if, before the sensation of one eye be exhausted, the slide shuts the lens and opens the other, a new impression is produced on the retina, and we have an uninterrupted sensation vision, as if the object had moved before us; and if a sufficient number of pictures represent that object in the various consecutive positions it has assumed during several stages of its motion, we experience on the retina the same sensation we have when we see the object itself while it is moving; and, although the pictures in their limited number do not, and cannot, show all the intermediate positions of all the stages of a continuing action, still the mind has the power of filling up the deficiency, as it does, if, when looking at a real object in motion, we accidentally wink the eyes, or an obstacle happens to pass before us and the object. Although during that short interval we have lost the perception of a certain progress of the action, the mind has, as it were, guessed and represented to itself what ought to have taken place during the winking of the eyes, or during the intervention of the passing obstacle, and by that power of the mind there has been no interruption in the whole perception.

This is exemplified in the most forcible manner when we have only two pictures to look at alternately—one with the right and the other with the left eye, as it is with the instrument I have constructed for my experiment. One of the pictures represents the beginning of an action, and the other the end of the same action. By moving the slide one way the right eye can see the picture representing the figure in one position, and the picture showing the other position is invisible to the left eye. Now, by moving the slide the other way the left eye sees the figure in the second position, and the first position is invisible

to the right eye. Now, although we have only seen the figure in two extreme positions—one showing the beginning of the action and the other its end—still we have had the illusion of having seen the intermediate positions.

This is fully illustrated by the pictures representing two boxers. In one picture the arms and fists of one of the pugilists are near his body, as if he were preparing to hit his opponent; and in the other picture they are extended in the act of striking the blow. We have not seen the intermediate position which the boxer ought to have gradually assumed during the whole fight, but we know that they must have taken place, and our mind completes the action. This mental perception is due to the sensation which we expect from habit and judgment, and we feel it as if it had been truly realized.

Another curious phenomenon is elicited by the alternate vision of the two eyes consecutively. We see the object without any difference or interruption, whether it be by the right or the left eye. The ultimate sensation on the mind is the same from whatever eye it has been carried to the sensorium of vision. Whether the object be seen by the right or by the left eye the sensation is exactly the same, and we cannot even distinguish which is the eye that has had the perception; so that if, while we have both eyes open, an object be passing before us, or if we move the hand before the eyes in such a manner that it hides alternately the vision of one and of the other eye, we do not feel that the vision is passing from one eye to the other, and it is impossible to know by which eye we have had the perception.

This explains the reason why, in the instrument I have constructed—which alternately shows a picture in one position to one eye and a different picture in another position to the other eye—we have a single perception of an object in motion without being conscious that the two actions have been consecutively and separately perceived only by one eye at a time, and in turn by one and then by the other. The result is an uninterrupted perception of an object in motion.

Our sensation of vision is not in the eyes, but only in the single sensorium of vision, to which both eyes convey their separate perception. We have an example of a similar physiological fact in the sense of hearing. Although we receive the sound from two organs in opposite directions, only one perception is felt by the mind; the two sensations, like two drops of water the moment they reach each other, are resolved into one.

If I have encroached too much on the time of the meeting, I have to offer an excuse, which I hope will be kindly accepted. How is it possible to be short when one principle of science irresistably leads us to another? And how can we stop when we begin to unfold the marvellous and innumerable expedients which the Creator has employed to make our senses perfect, and to help our intellect?

Translated for the Journal of the Franklin Institute.

Correction of Ship's Compasses at Sea.

M. Faye suggests to the Academy of Sciences at Paris, a method of determining at any time the error of the compass aboard a ship. This is done by attaching to the ship's log, which is suitably modified as to inclends and form, a compass so arranged that at any moment it may be stopped, and its direction thus registered. The log is towed in the wake of the ship, and at a sufficient distance to be out of reach of its magnetic influence, and when it has taken the true direction of the ship, which, if of proper shape, it will soon do, the compass is registered, hauled aboard, and read. The proposition assumes importance from the perpetual variation of the magnetic constants of iron vessels and sea, and the resulting impossibility of perfect correction of compasses.

In the course of his communication, M. Faye records a curious experiment, which is worthy of repetition and study: Dissolve in an acid, soft iron devoid of any magnetic coercitive force, and then deposit it, by a galvano-plastic process, in a thin film upon a surface of a plate of copper, as is done in coating copper plates with iron, to give them greater endurance. This thin coating of iron, chemically pure, but hard and brittle, will possess so strong a coercitive power that I have heated a plate thus prepared to the melting point of copper without destroying the magnetism which I had before given it.

New Mode of Preparing Formic Acid and the Formic Ethers.

By M. Lorin.

Heat a mixture of oxalic acid with dehydrated or commercial glycerine. At 75° Centigrade (167° Fahrenheit) the reaction begins and is in full activity at 90°, (194 Fahrenheit.) At the same time that carbonic acid is disengaged, a watery liquid passes over containing formic acid. On adding a fresh quantity of oxalic acid, some time after the evolution of carbonic acid has ceased, more liquid passes over and richer in formic acid, and, by successive additions of oxalic acid, the liquid becomes richer and richer in formic acid, until it reaches a limit which is exactly given by crystallized oxalic acid.

The equation $C_4H_2O_8, 4HO = C_2H_2O_4 + 4HO + C_2O_4$, shows that 126 grammes of oxalic acid give 82 grammes of aqueous formic acid, which ought to contain, and does in fact contain, 56 per cent. of absolute formic acid.

This preparation of formic acid is so continuous and regular as to be one of the easiest of chemical operations. It is useless to observe the temperature, for the development of carbonic acid indicates the beginning and the end of the operation.

To prepare formic acid of 75 per cent., I act upon glycerine saturated with dehydrated oxalic acid. But, in this operation, more care must be taken of the temperature, to avoid swelling, as the decomposition of the oxalic acid begins below 50°, (112° Fahrenheit.)

When, to the saturated glycerine, we add at the same time oxalic

acid, and the alcohol corresponding to the ether which we wish to obtain, and in about equivalent proportions, the reaction which I have before stated takes place, and the formic acid in its nascent state combines with the alcohol. It is better to condense the vapors within the retort, and not to distil until some time after complete decomposition of the oxalic acid. The ether is purified in the usual way.

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, October 18th, 1865.

The meeting was called to order with the Vice President, Professor Fairman Rogers, in the chair. The minutes of the last meeting were read and approved. The minutes of the Board of Managers were reported, including the following points of general interest:

Committee on Instruction have reported to the Board of Managers that the lectures will commence on Tuesday, 31st inst. Professor H. Morton lectures on Tuesday evenings on Mechanics, and Mr. Albert R. Leeds on Thursday evenings on Chemistry, for twenty weeks; and that arrangements are being made for some lectures to be delivered at the Academy of Music during the winter, of which due notice will be given.

The Executors of the estate of A. S. Roberts have notified the Board of Managers that Mr. Roberts has devised to the Institute $1000, to be paid in five yearly installments, to be appropriated to the purchase of books and the improvement of the library.

The following donations to the library were also reported: From the Society of Arts, London; the Board of Public Works, Chicago, Illinois; the Mercantile Library Association, New York; J. B. Lippincott & Co., and Professor John F. Frazer, Philadelphia.

The minutes of the various Standing Committees were then reported.

The Special Committee on Steam Expansion reported that their experiments had reached an advanced state of progress, and that a report embodying their results might be looked for at the next or following meeting.

A paper was then read by Mr. Brown on "The Problem of Aerial Navigation in its Mathematical Relations."

The report of the Secretary on new discoveries and inventions was then read as follows:

Secretary's Report.

Engineering Works.—On account of the great time which must yet be consumed before the Mont Cenis tunnel is finished, four and a half miles yet remaining to be executed, it is proposed to supply the break by a temporary track over the summit of the mountain. An experimental line of one and a fourth miles has been constructed on the most difficult portion of the route, with a view of testing the efficiency of this plan, and, as we see by the report of Captain Tyler, of the Royal

Engineers, sent out by the London Board of Trade to examine this work, this distance of one and a quarter miles is ascended in 8½ minutes with a load of 16 tons, though the average grade is so steep as 1 in 13, and at a maximum of 1 in 12. The plan adopted to obtain adhesion is an arrangement of horizontal drivers biting on a central rail.

This plan is much commended in the foreign journals, and is described as new, although to the best of my knowledge it was invented and patented in this country by a member of this Institute very long ago, and was used on some road in this State with satisfactory results. Some of the older members present can probably confirm and give precision to this general statement.

Mr. COLEMAN SELLERS.—The use of the two outside rails and one central adhesion rail, was patented many years ago by Mr. George Escol Sellers. The person to whom Prof. Morton alluded was Mr. Trautwine, the engineer of the Panama Railroad, who advocated the use of this plan across the Isthmus. The engines were so built, but the engineer who succeeded him concluded to cut down the road and use common engines. Since that, there was a road proposed in Pennsylvania, and two engines were built for the road in Cincinnati. An engine was run in New York on this plan, weighing 1100 pounds, which was capable of drawing 30 persons up a grade of 250 feet to the mile with ease. The plan on which they are constructed was better than that at present used in Europe, as they were so constructed that the whole weight of the train should act in producing adhesion, so that, the heavier the load, the harder the grip on the centre rail. We have at present in use at our own works a hammer operating upon the same plan, so that, the heavier the hammer used, the greater will be the bite of the wheels which lift it. I speak of this invention because I think it is due to America to say that it is purely American, and was advocated and used so long ago that the patent has expired; so that you can judge very well that we have precedence of any other country in this case.

Mechanics.—Under this head we would first call your attention to a new form of gas regulator, invented by Dr. Charles M. Cresson, of this city, claiming great delicacy of adjustment, and capacity to pass a large amount of gas, also compensating for the friction of service pipes by increasing the pressure automatically in proportion to the amount of gas passing through.

This regulator consists of a tank with the inlet and outlet pipes, I and O, passing up through the bottom to above the water level W. Within the tank is floated the gas holder H.

The adjusting valve V, secured to the gas holder by a loose link, is formed from a cylindrical plug (fitted loosely to a long cylindrical seat) having pyramidal excavations in its surface with their apices downwards towards the base of the valve. These excavations run out at different points, usually three in number; one extends entirely to the base. The next is two-thirds the length of the valve, and the third is one-third the length of the valve.

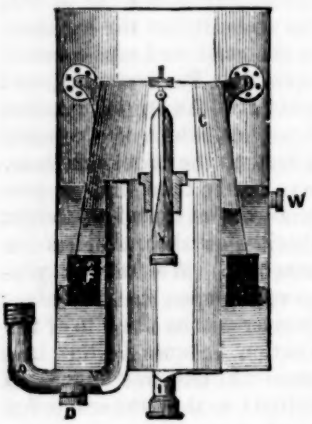
When the valve is but little open, the gas has passage only through

the triangular gutter found by the first excavation, and as the valve sinks to give a greater supply, this gutter gradually increases its sectional area until it is assisted by the second, and finally the third excavation.

In this manner a small amount of gas is passed through a channel of small dimensions and great length; but when a large amount is required, the valve presents the area of the three excavations, and at their largest section.

With ordinary pressures the valve has one inch of motion for use with one burner, whilst the two remaining inches will furnish a supply for twenty burners.

The gas holder H is a frustrum of a cone, the result of which form is to present to the lifting pressure of the gas a constantly diminishing area as it sinks into the fluid to open the valve, and consequently gives an increasing pressure whilst increasing the supply of gas. The amount of coning has been adjusted by experiment so as to increase the outlet pressure sufficiently to compensate for the loss of pressure in the fittings by the addition of many lights.



The fluid preferred for use in the tank is crude glyceringe, as it does not freeze easily nor evaporate, and has no corrosive influence upon the metal of the instrument.

The experimental trials made with the instruments were as follows:

For delicacy of adjustment. Gas was passed through the regulator to a branch upon which were burning twenty-one lights. All of these with the exception of one (a union jet at its maximum) were suddenly extinguished by a master cock, the single burner remaining without change, the pressure gauge showing a vibration of less than one-twentieth of an inch.

The pressure upon the inlet of the regulator was then increased successively to two and three inches without change upon the gauge upon the outlet of the regulator, as was also the case when one burner or all were lighted.

To show the result of checking off at the meter stopcock, as is frequently done where no regulator is used, the branch with the burners was connected directly to the street main without the intervention of the regulator, ten of the burners lighted, and the pressure adjusted by a stopcock to eight-tenths of an inch. When all but one were extinguished, the pressure rose to thirteen-tenths, the burner blowing. When twenty burners were lighted, the pressure fell to three-tenths of an inch.

An experimental trial was then made as to the quantity of gas consumed by the burners when under regulation to their maximum econ-

omy, and also the amount consumed by the same burners when subjected to the ordinary variations of street pressure, as observed during the present evening.

The result showed that with the regulator there was uniformly 78 cubic feet of gas per hour consumed by twenty-one burners, or 3·7 cubic feet per hour per burner. Whilst without the regulator the same burners consumed from 106 to 140 cubic feet per hour, the average being 126 cubic feet, or 6 feet per hour to each burner, the amount of light being not nearly proportionate to the increased cost. The burners being in the first instance properly adjusted to the wants of the consumer, all increase of light would be waste and loss.

Again we would call your attention to a plan for sharpening the teeth of saws, by grinding on a wheel of emery and vulcanite or hard rubber, the invention of Joseph F. Tuder, of this city. The effect of grinding on a wheel is, of course, to give a hollow face to the teeth, which causes them to cut better and for a longer time than when they are made flat or even rounded, as must be the case in filing.

The famous instrument maker of Paris, Deleuil, has brought before the French Academy an air pump in which all lubrication and packing are dispensed with. The piston is made very long, (twice its diameter,) is fitted very accurately to the cylinder, and has a number of horizontal grooves cut around its surface.

It is then found to be air-tight by reason of the capillary attraction of the air in the narrow space included between the cylinder and piston. With a small receiver on the pump plate, a vacuum of four millimetres of mercury can be obtained by this apparatus.

In the *Practical Mechanics' Journal* for September, we find the translation of an article on the mechanical puddler employed at the Closmortier forge, by MM. Dumeny and Lemut. This article is accompanied by many drawings, and is of great interest as showing the exact means employed in this important modification of iron working, and many of the results obtained by the new method.

A report has been made by the Société Industrielle de Mulhouse, on the Lenoir gas engine, the main conclusions of which may be thus briefly stated:

1st. That this motor consumes per horse power per hour 105 cubic feet, while a steam engine of like effect would consume 11 lbs. of coal in the same time.

2d. The gas engine requires an immense amount of oil, as much, in fact, as 2½ pints per horse power per day.

3d. The gas engine, again, requires constant and close attention on the part of the person running it, rendering it impossible for him to do any other work at the same time.

4th. The cost and care of the battery working the induction coil, which ignites the gas, is an item not included in steam motors.

All these are drawbacks to the machine in question. On the other hand, it presents the following advantages:

1st. It consumes fuel only while actually running. Thus, when

required for intermittent work, it may compare well even in economy with a steam engine, whose fire must be constantly burning.

2d. Its perfect freedom from danger.

3d. Its convenience of form, admitting of its introduction into any building, as it requires no furnace, fire, or the like.

Lastly, under this head of mechanics, we would bring to your notice this little apparatus called an atomizer, for scattering perfumed or medicated liquids in impalpable spray through the air of an apartment. It consists (as you see) of two glass tubes placed at right angles to each other, and kept in position by a little bracket of brass. We dip the longer of these in a vessel containing the liquid to be scattered, and then blowing through the other across the upper end of the first, produce a rarefaction in this, which causes the liquid to rise in it so as to be scattered in a fine mist from the upper end by the powerful blast of air. This instrument is invented by S. Maw, of London.

Optics.—Under this head we would introduce to your notice a plan for constructing cheaply large parabolic mirrors, of an enduring and light material, invented by Mr. J. Marshall.

In this case the frame or mould is formed of thick paper, moulded or otherwise worked into the required shape. To the inside of this are attached scales of mica, plated with metallic silver. The result is a reflector, light, durable, easily repaired, powerful in its reflecting action, and cheap in its first cost. Several of these mirrors, of various dimensions, were then exhibited, and their efficiency practically demonstrated. One of them, intended for lighting a skating pond, was four and a half feet in diameter.

Attention was here directed to a plan by which chemical and other reactions could be exhibited to a large audience, by the employment of a magic lantern, but the experimental demonstration of these was deferred until after the adjournment of the meeting.

Chemistry.—We have to notice two important plans for the preparation of the common alkalies directly from mineral substances found in great quantities and easily obtained.

Potash from feldspar. Feldspar, fluorspar, and chalk are pulverized, mixed, and calcined. Fluoride of silicon is disengaged, silicate of lime is formed, and the potash set free,—may be dissolved out by boiling water,—and freed from any lime present by carbonic acid. Some feldspars are, however, found to contain large quantities of soda, and yield on treatment that base.

Soda from cryolite. Cryolite and lime are pulverized and calcined, insoluble fluoride of calcium is formed, and a soluble compound of alumina and soda. This is dissolved out with water, which is then treated with carbonic acid, by which carbonate of soda is formed, and the alumina is precipitated. The Pennsylvania Salt and Alkali Manufacturing Company sent out last winter their chemical superintendent, Mr. Henry Pemberton, together with Mr. S. Lewis, to Copenhagen, where these gentlemen arrived about the 1st of December. They there made arrangements with the owners of the cryolite mines in Greenland,

Messrs. Shure & Sons, and with the Danish government, for the right of mining that material. Ships were then chartered in England, in Quebec, and in our own ports, to proceed to Ivigtus, Greenland, lat. 59°, load with the mineral, and bring it to this port. Six thousand tons have thus been imported up to this time, and a portion of the material is already undergoing treatment at the works of the company near Pittsburgh.

At the request of the members present, Mr. William Sellers then stated some of his observations during a late visit to England, as follows:

Whilst in England, I noticed great progress in all the industrial interests, the most remarkable being in the manufacture of steel. Formerly this business was confined to the manufacture of steel for cutlery purposes and other small objects, the use of it in large masses being unknown; but within the last six years, the general introduction of the Bessemer process, as well as that employed at Mr. Krupp's works in Germany, have revolutionized the trade, so that work which, under the old system, would require an immense number of hands, can now all be done upon the Bessemer plan by a few, making the steel thus produced comparatively cheap, so that it can be applied to ordinary purposes where iron has heretofore been used. It is probably true that this process will not produce the best quality of steel, but the material obtained is, at least, far better than any other equally cheap. By the Bessemer process, up to the point of converting into steel, labor is almost dispensed with, the operation of puddling being entirely abolished. The various movements required are all performed by hydraulic machinery controlled by one man, and it is interesting to see with what facility large masses of molten metal are handled, ten tons often being taken off at a heat. The pig metal is melted in an ordinary reverberatory furnace, and the speigleisen in another smaller one from which they are run into the converting vessel. This is a large egg-shaped vessel open at the top, and suspended upon trunions, so that it may be tipped upon an angle in order to bring its upper or open end under the spout, from which it receives its molten charge of iron. The bottom of this vessel is double, so as to form an air chamber, communicating through the trunions with the blowing cylinders, which produce the blast. The tuyeres are between the air chamber and the inside of the converting vessel, and when this is tipped on one side to receive its charge, the tuyeres will be above the molten iron. The blast is then applied, the converter tipped back to a perpendicular position, and the air rushes through the molten mass, burning out its carbon. When this is accomplished, the converter is turned on its side, the blast shut off, and the mouth passed under another spout to receive its charge of speigleisen. This produces a violent ebullition, and when this has subsided the conversion into steel has been completed.

The converter is now once more tipped upon one side, and the steel is poured into the ingot moulds, which are arranged in a semicircle about the centre of the hydraulic crane which carries the

converting vessel, the whole process being completed in almost as little time as it requires to describe it. After the ingots are sufficiently cool, they are removed to the heating furnaces, and from this point to the hammer or rolls, the subsequent processes are the same as in the manufacture of iron, although requiring machinery of more massive character, owing to the greater density of the material to be operated upon. In the process followed at Krupp's, and other similar works, the metal is melted in small pots, and then poured into one large enough to contain the quantity required for the intended casting, and from this it is let into the mould by withdrawing a plug in the bottom. I have seen gear wheels of excellent finish cast in this way, and large quantities of railway wheels and tires are thus made, the field for its use continually widening. The character of the steel made upon this process is as yet much superior to that made upon the Bessemer principle, and, it will be observed, there is one radical difference, the one rigidly excluding the air from the molten metal, whilst in the other, it is intimately mixed, but whether this is the cause of the difference in quality must be determined by more extended experience. Those engaged in the manufacture expected to make farther improvements, and from what I learned of their operations I believe that in a few years they will cast as large a piece as a twenty-inch gun of steel.

PROF. ROGERS.—They are making Bessemer steel in Troy, N. Y. Mr. Lamborn, of the Iron and Steel Association, is not here, or he would tell us something about it. Did you observe anything new in machine tools.

WM. SELLERS.—I knew they were preparing to make Bessemer steel there, but was not aware that any was produced as yet. The introduction of steel in masses has necessitated larger and stronger machine tools, but I did not observe any other change; that of size, however, is remarkable. Sir Wm. Armstrong's works, at New Castle, in the Ordnance Department, contain many fine specimens of tools, but they are for special purposes. The tools required for rolling and dressing cast steel tires are also remarkable for their enormous size and strength.

COLEMAN SELLERS.—Is the tire round, or is it necessary to turn it?

WM. SELLERS.—They turn it out on the inside at the works. They have made special machinery for the whole of this work, and nearly all steel tires as yet have been made from pot metal. The process of casting from pots is very interesting. From the great number of pots used, and the necessity of bringing them to the proper heat, and pouring into one reservoir at the same time, it is necessary to have all the men as thoroughly drilled as a regiment.

COLEMAN SELLERS.—You spoke of the movement of these large masses of metal. How is it accomplished?

WILLIAM SELLERS.—Entirely by hydraulic pressure. All the operations are performed in that way, excepting in the rolling of armor plates; in that case they use a traveling crane over head, and upon that

a steam engine and boiler. From this all the movements are obtained, the whole being under the control of one man.

The Vice President announced that the two turreted iron-clad *Monadnock* would leave the Navy Yard in a few days, for San Francisco, by the Straits of Magellan. She will be part of the squadron under the command of Commodore John Rodgers.

As she will go from north to extreme south magnetic latitude, and through a difference of longitude in which the declination of the needle will vary greatly, the opportunity of making observations connected with the permanent and variable magnetism of the ship and the action of her compasses will be an uncommonly good one.

Professor Harkness, of the Navy, late of the Naval Observatory, will go out in her, expressly for the purpose of making observations, which he may find necessary or possible.

The vessel will probably be swung at thirteen or more ports on the way, and careful shore observations will be made at the same points.

Altogether results may be expected which will materially extend our knowledge of the magnetic behavior of these new iron vessels.

The Vice President also mentioned that he had been experimenting lately with asphalte as a flooring for stables. The artificial asphalte, made from coal tar, such as is used in gravel roofs, was used, mixed with clean gravel in the ordinary manner, and laid on the hard clay to a thickness of two and a half inches, finer gravel being used at the top than at the bottom. The top was finished with a coat of hot, fine gravel, pressed into the asphalte, and the loose gravel swept off.

The use of the *artificial* asphalte for a floor for horses to stand upon, is believed to be new, and the result of the experiment as to wear will be reported after it has been tested.

The meeting was then, on motion, adjourned.

HENRY MORTON, *Secretary.*

BIBLIOGRAPHICAL NOTICE.

Curious Facts in the History of Insects. By FRANK COWAN. Philadelphia, Lippincott & Co., 1865. 12 mo. pp. 396.

An excellent little book, making no pretensions to technical science, but showing great industry and research on the part of the author, excellent taste in the selection of his materials, and good literary powers in presenting them. We found it very readable and amusing, and it is excellently presented to the public by the publishers. We hope this will not be the last we are to hear from the author.